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Technology-environment-employment linkages
and the rural poor of Bangladesh:
Insights from farm-level data

by

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Working Papers are preliminary material circulated to stimulate discussion
and critical comments

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Preface

This Working Paper is the fifth in a set of environmental papers presented by the World Employment Programme of the ILO and devoted to the analysis of the relationships between environment and development. The first paper was produced in January 1991. The present study concerns the environmental sustainability of the agricultural sector in Bangladesh and the associated risks for the maintenance of productivity and livelihood.

Following a brief overview of environmental and natural resource problems in rural Bangladesh, the paper presents and analyses the findings of three case studies drawn from separate villages in Bangladesh - one located on the floodplains in the (greater) Kushtia region and the other two located in the Chittagong Hill Districts. It considers the effects on income, income distribution, production, employment and the environment, of major technological changes in agriculture which have occurred in the villages. It provides concrete examples of the type of effects occurring on a much wider scale in Bangladesh, and does so for distinct areas. In the village selected in Kushtia, no forest exists. On the other hand, in the Chittagong Hill Districts forest still remains but is under considerable threat from extension and intensification of agriculture and from logging. The interface in the Chittagong Hill Districts between agriculture and forestry complicates decisions about natural resource utilisation, as do to some extent the differing agricultural practices. Of the two villages studied in the Chittagong Hill Districts, one belongs to Bengalis engaged in settled agriculture whereas the other belongs to a hill tribe which practices shifting agriculture. All of the villages studied face significant environmental problems.

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1 Introduction

It is now widely accepted that sustainable development is a desirable goal. While the concept of sustainable development has a variety of interpretations, discussions of the concept bring attention to the fact that short-term benefits from economic change may well be at the expense of future attainable levels of production or income. But sustainable development is not solely concerned with the question of sustaining GDP or growth of GDP. The concept of sustainability allows several interpretations (Tisdell 1988, 1990, 1991, 1992; Douglass 1984). It inevitably also involves the question of sustaining livelihoods and employment and raises broad questions about the measurement of welfare and appropriate goals for humanity.

As a result of this new focus in development policies, greater emphasis is being placed on environmental and ecological factors as constraints on economic production and as important factors to be taken into account in assessing new projects and economic changes. In particular, economic, environmental and natural resource interdependencies as well as resource-depletion problems are stressed as being important (Cf. World Commission on Environment and Development 1987). As a result, more account is being taken of environmental externalities and more accurate estimates of the real social benefits and costs of economic developments are being made. This is an important change because the nature of decisions depends not only upon how well data are analysed but most importantly on what data one chooses to collect for the analysis to take into account.

This paper provides farm-level evidence of environmental problems, which are to a large extent a result of technological change, and related economic issues in rural Bangladesh. While serious environmental problems do occur in urban areas, most of Bangladesh's population lives in rural areas and depend on these for their livelihood.

The focus of this paper is on major economic and associated environmental changes which have occurred in three rural villages of Bangladesh. These economic and environmental changes have all been associated with the adoption of new technologies and have had effects on production, employment, income distribution and the distribution of opportunities to earn a livelihood. These effects are documented to the extent possible in the limited time available for the collection of primary data from the villages. The specific results for these three case studies follows an overview of environmental and employment issues in rural Bangladesh.

2 State of the rural environment and trends

Rural Bangladesh has always had to cope with a large number of natural environmental problems which not infrequently have resulted in disaster for Bangladeshis. Because of Bangladesh's geographical location, these problems include floods, droughts and cyclones. To a considerable extent economic growth has magnified the effect of such natural disasters and has added to environmental problems in rural Bangladesh. This can be attributed both to economic developments and population growth in Bangladesh and to externalities or spillovers from economic developments and change in nearby countries such as India, Nepal

and China (Tibet). These have resulted in intensification of land- and water-use which in turn has had serious environmental effects as will be discussed below in some detail.

The following types of environmental deterioration have occurred in rural Bangladesh:

1. Increased fluctuations in flows of rivers and streams, resulting both in greater severity of flooding and reduced availability of water during drought or dry periods. There are also adverse consequences for navigation, fish stocks, siltation, water quality and so on.
2. Reduced availability of water (at least, in critical periods) e.g. due to greater demands on groundwater to irrigate high yielding varieties of crops which have been widely adopted following the Green Revolution and reduced water quality, e.g. salinization due to reduced inflows of freshwater into rivers and streams, or the leaching of nitrates into groundwater from artificial fertiliser use in the growing of crops.
3. Decline in soil quality due for example to the increasing incidence of multiple cropping. The humus content, structure and nutrient content of the soil can suffer from such practices. The use of artificial fertilisers can also increase soil acidity and destroy useful flora and fauna in the soil. Shahidul Islam (1990) points out that in Bangladesh "with most crops not only the edible portion (grain) is harvested but also the straw for fuel and fodder. The result is that soils are low in organic matter and depleted of nutrients... Bangladesh soils are hungry, sick and almost lifeless, they are in urgent need of organic matter to put life into them...".
4. Increased pesticide use especially of insecticides has had adverse environmental consequences. These include destruction of natural enemies of pests, induced resistance of pests to pesticides, adverse impact on populations of fish and because chemical such as DDT continue to be used, adverse consequences for wildlife. While the use of pesticides is low in Bangladesh compared to more developed countries such as Japan (Cf. Ameerul Islam 1990), the proportion of environmentally hazardous pesticides used, such as insecticides including organochlorides, is higher in Bangladesh. Controls on their use are also less stringent than in more developed countries.
5. Deforestation has increased due to logging, extension of agriculture in some areas and intensification of slash-and-burn agriculture which has reduced the length of the rotation cycle in 'Jhoom' cultivation. Deforestation has a number of serious environmental consequences such as greater fluctuations in river flows, more rapid erosion of soil and loss of wildlife which in turn results in reduced genetic diversity.
6. With the introduction of Green Revolution technologies and the increased adoption of high yielding varieties of crops, there has been a loss of traditional varieties of crops. These were usually well adapted to natural local conditions. As a result there is increased dependence on fewer varieties, the productivity of which may not be sustained or which can only be sustained under artificial environmental conditions such as achieved by irrigation and use of artificial fertilisers. Thus the genetic base of agricultural production is being reduced and this may make it difficult in the long run to sustain agricultural productivity (see for example Alauddin and Tisdell 1991).
7. Substantial reductions in stock of inland fish have occurred in Bangladesh as a result of environmental changes such as reduced water availability and quality in streams and rivers, draining and filling of water bodies, and to some extent as a result of greater chemical use in agriculture associated with the adoption of "Green Revolution" technologies. This has serious nutritional consequences because freshwater fish are the most important source of animal protein for Bangladeshis.

8. Indigenous wildlife continues to disappear mainly as a result of over-harvesting and habitat alteration. Habitat alteration is brought about by expansion and intensification of economic activity and by rising levels of human population in Bangladesh.

The incidence of environmentally related disease is high in Bangladesh and is to a large extent linked to faecal pollution of surface water. In Bangladesh, 80 per cent of illness has in fact been attributed to water-borne diseases (Haque and Hoque 1990). This incidence remains high in rural areas and, apart from the suffering which it causes, it is a serious economic impediment. In some parts of Bangladesh extension of the area under irrigation has added to the incidence of malaria by providing a more suitable environment for mosquito-breeding.

Several of these issues will be confirmed by farm-level studies in three villages in different parts of Bangladesh.

3 The three villages studied

The three villages studies are Durgapur located inland in the west of Bangladesh in greater Kushtia and two villages located in eastern Bangladesh in the Chittagong Hill Districts. The natural ecological-geographical conditions prevailing in the first village differ substantially from those in the other two villages. Durgapur is located on shallow floodplains with a distinct wet and dry season due to the monsoon. The other two villages are located in hilly areas and the annual rainfall is heavier and extends over a longer period of the year even though a dry period does occur (cf. Haroun Er Rashid 1991, p. 82).

If there were any substantial forests in the neighbourhood of Durgapur, they have long since disappeared and there is a severe shortage of fuelwood in the area. In the case of the villages in the Chittagong Hill Districts forest remains but is in the process of disappearing as a result of economic and technological change and development, the sustainability of which is being subjected to questions in this paper.

There is one important difference between the two villages studied in the Chittagong Hill Districts. In one case shifting agriculture is practised by tribal people whereas in the other settled agriculture is practised by Bengalis. Thus the effects of two different farming systems can be considered. However, both groups farm on forestry land in return for providing 80 days free labour per year to the Forestry Department. So their interface with the forest is a close one.

It should be noted however that the three villages studied here do not characterize the environmental and changing environmental conditions of all rural villages in Bangladesh. A larger group of villages would need to be selected to do this. For example, a floodplain village in which irrigation permits continuous or almost continuous supply throughout the year of rice or similar crops, has not been included. The village of Durgapur, although it is located on shallow floodplains, does not use irrigation to any significant extent and its cropping pattern is much more diversified than most villages on the floodplains in Bangladesh. Nonetheless, it has been affected by "Green Revolution" agricultural technologies.

Figure 1: Map of Bangladesh showing survey areas

In considering the experiences of Durgapur and the two villages from the Chittagong Hill Districts, particular attention will be paid to variations in exchange and non-exchange income obtained from the use of natural resources. As a result of technological change and economic growth, it often happens that while exchange income increases, non-exchange income falls (Alauddin and Tisdell 1989). This trend can be especially disadvantageous to the poor and the underprivileged, including the landless, women and children.

4 Agriculture in an unforested area on the floodplains: Case study from Kushtia

4.1 Introduction

This section presents an agricultural case study from an unforested village on the floodplains. We proceed first of all with a description of the survey area and method. This is followed by presentation of empirical results for land-owning households. Implications of technological and environmental changes for the rural poor consisting of the landless households are then discussed employing the concepts of exchange and non-exchange income. Environmental trends and the state of the environment in the village are considered along with their implications for rural poverty and sustainability.

4.2 Description of survey area and method

The data used in this study were derived from a direct sample survey. The collected data relate primarily to the crop year 1990-91. Employing a direct questionnaire method, farm-level data were collected with the aid of research assistants during September 1991. The survey village of Durgapur in the South Western district of (greater) Kushtia was selected purposively. We chose the village for (1) its relatively long tradition with HYV technology, (2) its easy access by road or train from the district headquarters and capital city of the country, (3) the reason of prior knowledge by one of the authors of this report of the village. A further reason is that the village is known to have had a very diversified cropping pattern and a large number of rice varieties were cultivated prior to the Green Revolution. The extent to which crop diversification has been sustained following the Green Revolution is one of the foci of interest.

Geographically, Durgapur belongs to the flood plains classified as shallow flooded areas (Hossain 1991, pp. 21-22). The area generally occupies the higher sites in the landscape, which are inundated to a depth ranging from a few centimetres to less than a metre during the monsoon.

The year 1990-91 was a fairly normal one for the village. Technologically the village is progressive compared to many other villages in the area. In all, 84 land-owning and 38 landless households were directly interviewed. These numbers constituted 80 percent of households in the respective categories. In the landowning class, 21 marginal (less than 1.00 acre), 29 small (1.00 to 2.50 acres), 26 medium (2.50 - 5.00 acres) and 8 large farmers

(5.00 acres and above) were interviewed. The number of farmers interviewed corresponded to the proportion of each category in the total population of land owners in the village.

4.3 Empirical analysis: Landowning households

The objective of this section is to analyse the empirical evidence obtained from the survey of the landowning households. We start with some observations on socio-economic characteristics of landowning groups in Durgapur. This is followed by analysis of cropping pattern, output and employment characteristics by various groupings of farmers.

4.3.1 Socio-economic characteristics

Table 1 provides information on selected socio-economic characteristics of these households, including family size, occupation, education level and average farm size of various landowning classes in our survey village. Several observations can be made from this Table. Average household size is positively associated with the size of the farm ranging from 5 for the marginal farms to 7.50 for the large landowners. Agriculture is the major occupation of the overwhelming majority (85%) of the households. Occupational distribution does not seem to differ significantly across farm size. Literacy level of the head of household increases significantly with farm size. Average area owned per household in the village is more than four times the average farm size for the marginal farmers (0.54 acre).

Incidence of sharecropping is insignificant as indicated by the average sizes of owned and operated holdings. As expected, average number of plots as well as their size are positively associated with the size of the farm.

Table 2 provides information on cropping pattern, average production per acre and labour intensity per acre for various crops.

It can be seen that:

1. In terms of area, jute is the major crop cultivated in the village (more than 33% of total land cultivated) followed by local *aus* (23%) and *aman* HYV (16%). The total area under cereals (rice and wheat) is nearly 51%, of which HYVs cover about 20% of the total area cultivated. Pulses (7%), sugarcane (6%) are the other major crops. This cropping pattern is very different from the one for Bangladesh as a whole.
2. Of the HYVs, *aman* HYV is the major crop cultivated by most of the farmers whose average yield is more than double the yield of the corresponding local variety.
3. In terms of labour intensity per acre, sugarcane ranks first with 120 mandays followed closely by *boro* HYV (118 mandays) and jute and *aman* HYV with 114 and 113 mandays respectively. Local varieties of *aus* and *aman* have more or less similar labour requirements per acre. Pulses and oilseeds do not feature prominently in terms of employment generation even though they are nutritionally important. These two crops have respective labour requirements per acre of 15 and 18 mandays.

TABLE 1

SOCIO-ECONOMIC CHARACTERISTICS OF LAND-OWNING CLASSES: DURGAPUR 1990-91

Farm Size (ac)	No. of Samples	Average family size (no.)	Major occupation (in percent)		Literacy level of head of household (percent) Ill.* Lit.**	Average area owned per household (ac)	Average area operated per household (ac)	Average number of plots per household	Average size of plot (ac)	
			Agriculture	Others						
Less than 1.00	21	4.95	85.71	14.29	85.71	14.29	0.54	0.57	2.38	0.23
1.00 - 2.50	29	5.62	75.86	24.14	86.21	13.79	1.55	1.53	3.41	0.45
2.50 - 5.00	26	6.65	92.31	7.69	61.54	38.46	3.38	3.36	4.15	0.81
5.00 and above	8	7.50	87.50	12.50	37.50	62.50	7.33	5.31	6.38	1.15
Total	84	5.95	84.52	15.48	73.81	26.19	2.41	2.21	3.67	0.66

* illiterate

** literate

TABLE 2
CROPPING PATTERN, PRODUCTION AND LABOUR REQUIREMENTS
IN CROP PRODUCTION: DURGAPUR 1990-91

Crop	Area under crop		Average production per acre (maunds)*	Average labour requirements (mandays)
	Total (ac)	Percent		
Jute	73.05	33.42	29.56	114
Aus local	50.58	23.14	21.09	99
Aman HYV	35.26	16.14	46.09	113
Aman local	16.03	7.34	21.94	103
Pulses	15.71	7.19	6.57	15
Sugarcane	13.32	6.10	260.05	120
Boro HYV	5.89	2.70	26.85	118
Wheat HYV	3.48	1.59	25.66	50
Oilseeds	3.22	1.47	5.18	18
Others	1.99	0.91	-	50
Total	218.53	100	-	-

* 1 maund equals 82lbs approximately.

Table 3 presents survey results on the distribution of land, cropping intensity and percentage of HYV area in rice cultivation by groupings of farmers. It highlights the following:

1. The distribution of operated land over farm size is highly unequal: the lowest 25% operate only 6.4 percent of the land while the top 10 percent operate nearly 23% of the land. The distribution of cultivated area follows a broadly similar pattern.
2. The average intensity of cropping is 117 percent which is appreciably lower than the national average (more than 150 percent). The variations in intensity of cultivation among farm size shows the highest for the top landowning class (128 percent).
3. On an average, more than 49 percent of total cultivated land is under rice and this percentage increases with farm size. In terms of percentages of land, marginal farmers (less than 1 acre) allocate 37 percent to cultivation of rice which increase to 57 percent for the large farmers (with land area 5 acres and above).
4. The smallest and the largest farms have the highest percentages of rice area under HYVs: 47% and 46% respectively.

TABLE 3
LAND DISTRIBUTION, CROPPING INTENSITY AND INTENSITY OF
HYV RICE ADOPTION BY FARM SIZE: DURGAPUR 1990-91

Farm size (ac)	Operated area		Cultivated area		Intensity of cropping (percent)	Percentage of rice area in total cultivated area		Percentage of HYV rice area in total area under rice	
	Total (ac)	Percent	Total (ac)	Percent		rice area in total	cultivated area	rice area in total	area under rice
Less than 1.00	11.98	6.44	13.90	6.36	116.03	37.38		46.94	
1.00 - 2.50	44.29	23.81	52.14	23.86	117.72	42.75		38.50	
2.50 - 5.00	87.31	46.93	98.13	44.91	112.39	50.01		32.36	
5.00 and above	42.46	22.82	54.35	24.87	128.00	57.42		45.66	
Total	186.04	100	218.52	100	117.46	49.32		38.18	

In Table 4 we set out data on land area allocated to various crops by different classes of farmers. The following aspects are noted.

First, jute is the major crop in terms of area cultivated for all classes of farmers. The intensity of jute cultivation varies inversely with farm size. The marginal farmers allocate nearly half the land to jute cultivation compared to only a quarter by the large farmers. On the other hand, the percentage of area allocated to cereals (rice and wheat) varies directly with farm size. While the lowest farmer group devote 37 percent of the cultivated area to cereal production the highest farmer group allocates 59% of their land area.

Second, the intensity of HYV adoption seems invariant with size even though it is appreciably higher for the largest group (17 to 18 percent of cultivated land area for all farmer groups except the largest for which the percentage is 27).

Third, crops like pulses and oilseeds seem to be more important for smaller farm size classes in relative terms although in absolute terms larger farm size classes cultivate more land under these crops. The annual crop, sugarcane, is cultivated more extensively by large farm size classes with the proportion in total area cultivated increasing with farm size.

Table 5 shows the seasonal distribution of land cultivated by different classes of farmers. Small farmers tend to concentrate on cultivating their land more during the *aus* season. The percentage of total land allocated to crop production during the *aus* season appears to decrease with the size of the farm. The opposite seems to be the case during the *aman* season. Larger farmers allocate higher percentage of land to *aman* rice cultivation. During the *boro* season no discernible trend seems to be present even though the percentage of land area allocated to *boro* crops by the large farms is marginally lower than the ones for other groups.

Table 6 gives labour requirements for major crops by different farmer groups. There does not seem to be any significant difference in intensities of labour use by various farm groups although in general smaller farmer groups tend to apply more labour per acre of land. Possibly, this is because the smaller groups are better endowed with labour resources than the larger ones.

Labour requirements of some of the major crops (e.g. jute, *aus* local, *aman* local, *aman* HYV, *boro* HYV and sugarcane) are significantly higher than other crops like pulses and oilseeds. Transfer of land from the latter crops, even though undesirable from nutritional point of view, increases employment.

Table 7 gives yields of major crops by farmer groups. It can be seen that the differences in yields per acre of different crops in relation to farm size do not reflect any discernible pattern. In most cases yields per acre for small farms seems to be higher compared to large farms. The differences in yields between local and HYV of crops (e.g. *aman* local and *aman* HYV) is quite substantial indicating high output potential of HYVs.

TABLE 4

AREA UNDER MAJOR CROPS BY LANDOWNING CLASSES: DURGAPUR 1990-91 (ACRES)

Crop	Group 1 (Marginal)		Group 2 (Small)		Group 3 (Medium)		Group 4 (Large)	
	Area	Share in total area cultivated (percent)	Area	Share in total area cultivated (percent)	Area	Share in total area cultivated (percent)	Area	Share in total area cultivated (percent)
Jute	6.72	48.35	20.18	38.70	32.54	33.16	13.61	25.04
Aus local	2.51	18.06	11.88	22.78	22.87	23.31	13.32	24.51
Aman local	0.25	1.80	1.83	3.51	10.32	10.52	3.64	6.70
Aman HYV	2.27	16.33	7.84	15.03	11.90	12.14	13.25	24.38
Boro HYV	0.17	1.22	0.74	1.42	3.98	4.05	1.00	1.84
Pulses	1.73	12.45	6.21	11.91	5.78	5.89	1.98	3.64
Oilseeds	0.25	1.79	0.66	1.27	1.65	1.68	0.66	1.21
Sugarcane	-	-	2.31	4.43	6.44	6.56	4.57	8.41
Wheat HYV	-	-	0.50	0.95	2.32	2.36	0.66	1.21
Others	-	-	-	-	0.33	0.34	1.66	3.06
Total	13.90	100	52.15	100	98.13	100	54.35	100

Note: Group 1 refers to farm size class owning land less than 1 acre, Group 2 is class with land 1 to 2.5 acre, Group 3 with land 2.5-5 acre and Group 4 is the class with land of 5 acre and more.

TABLE 5

SEASONAL DISTRIBUTION OF LAND CULTIVATED BY DIFFERENT FARMER CLASSES:
DURGAPUR 1990-91

Farm Size (acres)	Annual	SEASONS			Total
		<i>Aus</i> Season	<i>Aman</i> Season (percentage of cropped area)	<i>Boro</i> Season	
Less than 1.0	-	66.41	18.15	15.44	100
1.0 - 2.5	4.43	61.49	18.53	15.55	100
2.5 - 5.0	6.56	56.45	22.64	14.34	100
5.0 and above	8.41	49.55	31.07	10.97	100
Total	6.09	56.58	23.47	13.86	100

TABLE 6
LABOUR REQUIREMENTS FOR MAJOR CROPS: DURGAPUR 1990-91 (MANDAYS PER ACRE)

Farm Size (acres)	Jute	Aus local	Aman local	Aman HYV	Boro HYV	Sugarcane	Pulses	Oilseeds
Less than 1.00	118	99	96	115	120	-	18	21
1.00 - 2.50	114	103	90	111	120	127	17	19
2.50 - 5.00	113	97	105	114	120	112	14	16
5.00 and above	112	96	108	114	111	123	14	17
Average for all classes	114	99	103	113	118	120	15	18

TABLE 7
YIELDS OF MAJOR CROPS: DURGAPUR 1990-91 (MAUNDS PER ACRE)

Farm Size Wheat HYV (acres)	Jute	Aus local	Aman local	Aman HYV	Boro HYV	Sugarcane	Pulses	Oilseeds
Less than 1.00	29.76	22.60	22.10	50.57	24.24	-	8.03	4.03-
1.00 - 2.50	30.92	20.53	23.55	52.25	27.66	277	6.53	6.0624.24
2.50 - 5.00	25.11	22.17	20.83	45.29	28.64	230	7.17	6.0616.38
5.00 and above	32.44	19.07	21.43	36.23	273	273	4.55	4.5536.36
Average for all classes	29.56	21.09	21.94	46.09	26.85	260	6.57	5.1825.66

4.4 Empirical evidence: Landless households

In this section we present evidence about the incidence of landlessness and some characteristics of landless households in Durgapur. At the time of conducting the survey, 48 households out of a total of 150 were estimated to be landless. The incidence of landlessness (about a third) in the survey village is similar to the figure for Bangladesh as a whole (BBS 1986).

4.4.1 Incidence of landlessness: Some characteristics

Table 8 sets out relevant information about landless households in the survey area. The bulk of the landless households did not inherit any land. Many landless householders' fathers were landless (about 42 percent of the sample). Those households who inherited some amount of land (18 percent) became landless during their lifetime. A little over 34 percent of their land was sold off to maintain family while the remainder was sold off to meet expenses for medical treatment, daughters' marriage, purchase of bovine animals and due to defrauding.

Over 90 percent of the landless households work as agricultural labourers, very few having subsidiary occupation. About 45 percent of the sample households cultivated land under sharecropping arrangements. The average amount of sharecropped land per household is very small (only 0.25 acre).

More than half the landless households in our survey do not have any homestead land. For those who have some, the amount is very small (0.042 acre on average) and not sufficient to have a vegetable garden. Over 75 percent of those interviewed reported having some domestic animals and poultry birds. However, their number has, in most cases, remained much the same over the years. Their number is limited by the shortage of grazing land and inadequate supply of feed. Most households (over 84 percent) reported indebtedness, the average size of loan being nearly Tk1200. The purpose of the loan is primarily consumption even though households borrowed money also for business purposes. It is noted that borrowers pay very high rates of interest, ranging from 5 percent to 20 percent per month.

We do not have any hard evidence to indicate whether landlessness is on the increase in the survey village. But the process through which marginal and small farmers in Durgapur and elsewhere became landless, e.g. distress selling (Alauddin and Tisdell 1989; Rahman 1982), suggests that as demographic pressure and institutional arrangements (e.g. law of inheritance) reduce the size of land holdings, adverse economic circumstances are more likely to force smaller owners to dispose of their land (Alamgir 1980, pp. 159 et seq.). As Cain (1983, p. 154) argues: "...the lower end of the distribution is a sensitive indicator of change. There seems to be a process of polarisation whereby the near landless are dispossessed and join the ranks of the landless while small farmers in turn become near landless."

TABLE 8

CHARACTERISTICS OF LANDLESS HOUSEHOLDS IN A
BANGLADESHI VILLAGE: DURGAPUR 1990-91

	<u>Characteristics</u>	<u>Number¹</u>	<u>Percentage</u>
1.	Average family size: 4.13	-	-
2.	Education level of head of household: literate	1	2.63
3.	Households not inheriting any cultivable land	31	81.58
a.	Father did not inherit any land	13	41.94
b.	Father became landless during his lifetime or did not give any land to his son	18	58.06
4.	Households who inherited/had land but became landless	7	18.42
5.	Total land area sold off in the process of being landless: 5.41 acres		
a.	To maintain family: 1.84 acres		34.01
b.	Due to daughter's marriage, medical treatment, defrauding and purchase of draught animals: 3.587		65.99
6.	Major occupation		
a.	Agricultural labour (including day labour)	35	92.11
b.	Others (including rickshaw pulling, petty trading, service)	3*	7.89

TABLE 8 (CONTINUED)

	<u>Characteristics</u>	<u>Number¹</u>	<u>Percentage</u>
7.	Subsidiary occupation		
a.	None	32	84.21
b.	Agricultural labour (including day labour)	0	-
c.	Others (including rickshaw pulling, petty trading, service)	6	15.79
8.	Incidence of sharecropping		
a.	Households operating land under sharecropping	17	44.74
b.	Amount of sharecropped land per sharecropping landless household 0.25 acre		
9.	Households reporting:	29	76.32
a.	Bovine animals	2	5.26
b.	Goat-sheep	16	42.10
c.	Poultry birds	25	65.79
10.	Homestead land		
a.	Number of Households owning homestead land	18	47.37
b.	Average size of homestead land: 0.042 acre		
11.	Number of households reporting indebtedness	32	84.21
	Average loan: Taka 1194		
	Interest rates: (range between 5 percent per month to 20 percent per month)		

1. Number of households interviewed: 38
* Including one disabled

4.5 Employment in crop production and daily wage rate: Seasonal dimensions - Durgapur

The objective of this section is to present the employment implications of the new agricultural technology at the farm-level especially in terms of its seasonal distribution. Macro level studies on employment from crop production suggest that seasonal differences in labour demand since the Green Revolution have declined over the years (Alauddin and Tisdell 1991a; Khan 1985; Chaudhury 1981). This is because cultivated land that was once left fallow or allocated to relatively less labour intensive crops during the dry season is now used for crops like *boro* rice or wheat which are relatively more labour intensive. This is an important way in which the Green Revolution technology had added significantly to agricultural employment and may have reduced the seasonal incidence of poverty.

In the case however of Durgapur, little *boro* rice is grown due to lack of irrigation. It therefore is not typical of the majority of floodplain villages and one would not expect a reduction in fluctuation in seasonal employment as a result of adoption of Green Revolution technology in villages like it which still depend more on rainfed crops. Nonetheless, its production of rainfed crops has been affected by Green Revolution technology. For example an increasing proportion of *aman* HYV rice is being grown in the wet season and a limited amount of other HYV is also being planted. Fertiliser and pesticide use has also increased. In fact in this village because of the dependence of crops on rainfall, Green Revolution technologies appear to have added to demand for labour in the six months of the year (April to October) with little impact on demand in the remainder of the year. Thus seasonal fluctuation in demand for labour appears to have risen in the case of this village and this may be common for rainfed dependent villages (Cf. Alauddin and Tisdell 1991a).

Table 9 sets out relevant information on overall labour demand from cereal and non-cereal crop production on a monthly basis. Also set out are the relative shares in the respective totals. Table 9 further presents information on the monthly variation of average daily wage rates reported by the landless. The Table suggests the following.

1. Overall labour intensity is 100 mandays per acre with little difference between labour intensity for production of cereal and non cereal crops. The overall figure is consistent with the one for Bangladesh as a whole. The cereal crops are overwhelmingly dominated by rice, primarily *aus* rice. Non cereal crops on the other hand are dwarfed primarily by jute and to a small extent by sugarcane, both being relatively labour-intensive crops.
2. The seasonal distribution of employment in crop production is highly skewed. More than half of the labour demand for crop production is concentrated during the months of *Jaishtha* (mid-May to mid-June), *Asharh* (mid-June to mid-July) and *Bhadra* (mid-August to mid-September). This is generally true for cereals as well as for non cereals. Overall leanest months are *Agrahayan* (mid-November to mid-December), *Magh* (mid-January to mid-February), *Falgun* (mid-February to mid-March), *Chaitra* (mid-March to mid-April) and *Sravan* (mid-July to mid-August). The pattern is clear from Figure 2.
3. There is significant monthly variation in daily wages. Wage rates are not consistently related to the distribution of employment from crop production activities. This could be explained because when crop production activities are at a low ebb, opportunities for some other types of employment are available, e.g. rural housebuilding, petty trading, transportation services.

TABLE 9
MONTHLY DISTRIBUTION OF EMPLOYMENT FROM CROP PRODUCTION AND DAILY WAGE RATE: DURGAPUR 1990-91*

Month	Total	EMPLOYMENT (Man days)		Percentage Distribution of		Daily Wage (Taka)			
		Cereal	Non cereal	Total	Cereal	Non cereal	Low	High	Normal
1. Baishakh	2088	809	1279	9.56	7.48	11.61	25	30	20
2. Jaishtha	3383	1274	2109	15.50	11.78	19.15	20	25	15
3. Asharh	4279	1608	2671	19.60	14.87	24.25	20	25	20
4. Sravan	1291	1291	0	5.91	11.94	0.00	15	20	15
5. Bhadra	5621	3596	2025	25.75	33.25	18.38	30	35	20
6. Ashwin	1569	1020	549	7.19	9.43	4.98	15	20	15
7. Kartik	690	42	648	3.16	0.39	5.88	20	25	20
8. Agrahayan	1240	637	603	5.68	5.89	5.47	20	25	20
9. Poush	968	432	536	4.43	3.99	4.87	20	25	20
10. Magh	326	3	323	1.49	0.03	2.93	25	30	20
11. Falgun	163	0	163	0.75	0.00	1.48	20	25	20
12. Chaitra	213	104	109	0.98	0.96	0.99	15	20	15
Total	21831	10816	11015	100.00	100.00	100.00			
Mandays per acre	100	97	103						

(Note: Baishakh means mid-April to mid-May; Jaishtha, mid-May to mid-June, etc.)

* for sample households only.

Figure 2: Percentage Distribution of Total Employment by Month: Durgapur 1990-91

1 = Baishakh (mid-April to mid-May)

2 = Jaishtha (mid-May to mid-June)

3 = Asharh (mid-June to mid-July)

4 = Sravan (mid-July to mid-August)

5 = Bhadra (mid-August to mid-September)

6 = Ashwin (mid-September to mid-October)

7 = Kartik (mid-October to mid-November)

8 = Agrahayan (mid-November to mid-December)

9 = Poush (mid-December to mid-January)

10 = Magh (mid-January to mid-February)

11 = Falgun (mid-February to mid-March)

12 = Chaitra (mid-March to mid-April)

4.6 Environmental trends and the state of the environment - Durgapur

4.6.1 Introduction

Increased population, extension of markets and spreading of new technologies have had considerable influence on the state of the rural environment in many parts of the world. Loss of soil quality and fertility, depletion of natural resources, adverse impact on surface and ground water, loss of trees and vegetation, fuel and energy, fish stocks and genetic diversity have occurred following the Green Revolution (Conway 1985; Jodha 1985, 1986; Repetto and Holmes 1983; Biggs and Clay 1981). Empirical studies have reported adverse environmental consequences of the new agricultural technology in Bangladesh. These include, among other things, lowering of ground water level beyond the suction limit, loss of fish output in paddy fields and other water bodies, loss of natural soil fertility, increasing dependence on narrow range of genetic materials (M. Ahmed 1986; M.F. Ahmed 1986; Hamid et al. 1978; Jones 1984; Tisdell and Alauddin 1989; Alauddin and Tisdell 1991b).

The objective of this section is to investigate whether there is farm level evidence from Durgapur of such trends.

4.6.2 Environmental changes

Over the years growth in population has led to extension of human habitation to cultivable or cultivated areas. Marginal land area has been brought under cultivation by clearing jungles and bushes, destroying or at least disturbing habitats of wildlife in the area.

During the last 2-3 decades, especially in the last 20 years, a number of fruit trees like mango and jackfruit, *Khejur* palm (*Phoenix sylvestris*), *jam* (*Syzygium jambolana*), *Tal* palm (*Borassus flabellifer*) have been cut down for fuel wood for use in the urban centres as well as for commercial brick kilns. Today one notices few fruit-yielding trees compared to a multitude some twenty years ago. In the last few years, however, the relatively wealthy farmers in the village have begun to plant *Shisham* (*Dalbergia sissoo*). This has a high value for timber and is quite profitable to grow.

Livestock populations, including those of sheep, goats and poultry, have remained stationary or have even declined slightly. This is primarily due to: (1) a significant decline in area under fodder crops; (2) the virtual disappearance of pasture and grazing land; and (3) a shift from long-stem to short varieties of rice cultivation (e.g. *aman* local to *aman* HYV). Furthermore, the rapid depletion of trees such as *Banyan* (*Ficus bengalensis*) and *Oshot* (*Ficus religiosa*) and *Acacia* has led to the decline in the supply of green leaves and fruit which are used as fodder for sheep, goats and cattle. If this trend continues, it is unlikely that the population of livestock and poultry will increase in the future. Indeed there are signs suggesting that it may decline further.

Indiscriminate use of pesticides and insecticides has affected fish output from the paddy. It was found during the course of fieldwork that fish production in the paddy fields has declined by about two-thirds over the last ten years. In our survey village, some farmers engage in commercial culture of exotic fishes. Even though these are high yielding, they are susceptible to diseases and are inferior in taste. The supply of indigenous species of fish has declined. The use of agrochemicals interrupts natural breeding and causes discontinuity in

the life-cycle of fish. Furthermore, reclamation of *beels* and low lying areas for rice production has contributed to a reduction of habitat of local fish.

The new agricultural technology has had several other environmental spillovers. These include:

1. Natural soil fertility has been affected adversely due to inappropriate application of chemical fertilisers. Greater quantities of chemical fertilisers are now needed to maintain crop yields. Due to stagnation (if not a reduction) in livestock populations, the supply of cow dung for use as an organic manure has not increased. Furthermore, as a result of decline in the availability of fuel wood, cow dung is increasingly used as a cooking fuel. Furthermore, loss of trees has resulted in the drastic reduction of tree leaves that could be used as green manure. The nutritional imbalance suffered by the soil has increased dependence on chemical fertilisers at the expense of renewable sources.
2. The cropping pattern described in Table 2 indicates that a wide variety of crops is grown in the survey village. This however masks the impact of Green Revolution technology in terms of loss or narrowing of genetic diversity. New varieties of rice have driven several indigenous rice varieties out of use. Fewer strains of rice are now cultivated than prior to the Green Revolution. The cultivation of HYV *aman* rice relies almost exclusively on a single variety, viz. BR-11. Furthermore, a variety of pulses and *Arhar* (Pigeon Pea) are no longer grown.
3. The Green Revolution has added to a proliferation of weeds. The continued application of pesticides has met with the development of resistance. Moreover weedicides and insecticides have affected non-target populations, e.g. predators and parasites that might prove beneficial to human beings. For instance increased use of chemical agents has much depleted the frog/toad population. As a result, the need for insecticides has increased.

Under normal circumstances increased crop production tends to generate greater employment. Agricultural employment has increased slightly even though there is very little agricultural activity during the dry season. Non-agricultural employment has increased somewhat as a result of infrastructural development. Improvement of the main road linking the village to the nearest urban centre has given some villagers the opportunity to engage in small businesses and provide transportation services. Precise quantification of non-agricultural employment is not possible. However, during the course of the field survey it was gathered that on average a labourer is currently employed for around 250 man days a year. In Table 9 we presented an estimate of total agricultural employment of 21831 man days per year. Given about 100-110 wage labourers in our sample, the per capita agricultural employment ranges between 200-220 man days per year. Thus a total of 30-50 man days of non-agricultural employment per head seems to have resulted from the changes that followed the Green Revolution and infrastructural development. The respondents indicated that annual employment opportunities per labourer on average has increased from 150 man days to 250 man days during the period. About 30-50 percent of this increase has resulted from expanded non-agricultural employment opportunities. However this gain seems to have been achieved at the cost of a decline in environmental quality. Stagnant water due to poor and inadequate drainage from roads, for example, has created breeding grounds for mosquitoes with adverse effects on health.

4.7 Environmental change: Implications for rural poverty and sustainability

In the light of the preceding discussion about changes in the environment of our survey village, several questions emerge: What implications do these changes have for the rural poor? Are the increased employment opportunities adequate to compensate for the loss in environmental quality? Has the physical quality of life for the poorer sections of the rural community improved since the advent of the new technology?

It has been argued elsewhere (Alauddin and Tisdell 1989; Jodha 1985, 1986; Lipton 1985; Conway 1985) that the income of the rural poor consisting of the landless and the near-landless has two components:

- (1) Exchange income: Primarily wage income determined in the main through the market mechanism.
- (2) Non-exchange income: Determined in the main by institutional/sociological systems in the rural community and usually obtained directly from nature without exchange. It includes, among other things, wild fruits, firewood, building and thatching materials, water from tanks and ponds for growing vegetables, free-ranging of poultry and some grazing land for sheep, goats and cattle.

The sources of the exchange component depend on the general level of economic activity (both agricultural and non-agricultural). On the other hand the extent of non-exchange income depends primarily on common access or low-cost access to natural resources. It is claimed that the non-exchange component of income could be important in the off-peak periods and is even more significant in abnormal years when both the period of employment is shortened and real income falls result in reduced exchange entitlement (Sen 1981). In other words, the exchange and non-exchange components complement each other and in adverse circumstances the latter component acts as a buffer.

Our empirical evidence from the survey indicates that following the Green Revolution the scope and opportunity for exchange income has increased quite significantly. On the other hand, it seems that the scope for non-exchange component income has declined. Available resources for supply of non-exchange income appear to be becoming scarcer in Durgapur. Population pressure and technological forces have depleted them and greater penetration of technological and market forces may have led to some resources being priced which were previously free or freely accessible. Although our data base is limited and quantification must await further research, the evidence in Durgapur indicates reduced availability of non-exchange income.

Fish stocks in the paddy fields have fallen or disappeared. Depletion of fish stocks in the paddy fields implies that an important source of supplementary employment, especially in the leaner months, has disappeared. Thus an important source of supplementary income for many wage labourers or low-income earners has disappeared while also reducing the opportunity to supplement the diet with animal protein.

The role of women and to some extent children in supplementing income from formal and informal sources has been undermined in a number of ways. Reasons include:

1. Restrictions on animal husbandry and free-ranging of poultry.
2. Loss of opportunities to collect wild fruits and firewood due to the dwindling supply of these resources. It now takes 2 - 3 times as long to collect fuel as in the past.
3. Loss of opportunities for rice processing (from paddy to rice) by traditional methods (*Dheki*). These have been replaced by labour-saving modern methods. The traditional labour-intensive method of oil milling has also gone out of existence.

Cropping patterns discussed earlier suggest greater dependence on jute cultivation by the smaller farmers. This is partly because of the requirement for cooking fuel and thatching materials, and partly because they are better endowed with family labour. Moreover, jute cultivation does not require as much purchased input as rice. Farmers however are finding it increasingly difficult to access surface water for raw jute processing (retting, that is the process of separating jute pulp from its fibre). Although that is a general problem, it is more acute for the smaller farmers in the village. Currently processing is done in the standing water of bigger ditches in the village causing considerable environmental pollution.

Health risks resulting from environmental pollution can hardly be over-emphasised. We have seen earlier in this paper that a very important cause of becoming landless is the requirement of medical treatment. If environmental change leads to increased incidence of diseases such as malaria, it may increase the ranks of the landless.

Loss of genetic diversity raises doubts about sustainability of production. Dependence on a narrow range of genetic resources could be disastrous if there is a sudden widespread outbreak of any plant disease or pest or insect attack. Furthermore, reduction in the availability of organic/green manure is likely to lead to a decline in soil quality. While wealthier farmers may be able to replenish soil nutrients using purchased inputs, the smaller farmers may find it difficult to do so because of their limited resource base. This may result in the soil of smaller farmers declining more rapidly in fertility. Constant effort is therefore required to sustain production and employment opportunities in modern agriculture (Cf. Johnston and Cownie 1969; Dhikawa 1978) and there is always the possibility of the whole system collapsing.

5 Agriculture in a forested area: Case studies from Chittagong Hill Districts

5.1 Introduction

In parts of Bangladesh, especially in the Chittagong Hill Districts, forestry and agriculture are inextricably linked. Technological, environmental and other changes have profound influence on the way of life of the people in those areas. In this section we provide empirical evidence of changes since the introduction of the new agricultural technology in two forested areas of Chittagong Hill Districts where agriculture and forestry interact. In doing so we seek to provide answers to questions including: How sustainable is economic development in the area? Is it becoming more difficult to maintain rice yields? What environmental problems are emerging, e.g. erosion, variability of water supply? Is there any evidence of growing difficulties in sustaining employment and livelihood, e.g. amongst

particular groups? Is there any evidence of loss of genetic diversity in agricultural crop production? Is wildlife and its habitat being threatened by environmental and other problems?

5.2 Survey areas: Description and method

Two relatively diverse areas in Chittagong Hill Districts were selected for field work. One of the areas was dominated by shifting agriculture while the other is characterised by settled agriculture. People in both areas engage in varying degrees of gathering, hunting and use of free or common-access resources in the forest.

Data were collected with the help of research assistants during August-September in 1990-91. The collected information relates to the 1990-91 crop year. Farmers and forestry officials were interviewed in both areas on the basis of questionnaires. In the settled agricultural area, 35 farmers were interviewed while 31 farmers were interviewed in the area dominated by shifting agriculture. The former area is inhabited primarily by the Bengalee people while the latter is inhabited by tribal people. None of the farmers in any of the two areas owned any land of their own. Farmers cultivate Forestry Department land and keep the entire produce on condition that they must provide around 80 days of free labour for plantation and maintenance of state forests.

5.3 Empirical evidence from the survey areas

5.3.1 Socio-economic characteristics

This section outlines some socio-economic characteristics of the villages surveyed in the Chittagong Hill Districts. Table 10 sets out relevant information on these aspects for the farmers in the area with settled agriculture. First, 80 percent of the households belong to farms of between 1.0 to 3.5 acres. Second, average family size for all farm size classes are higher than the national average and tend to rise directly with the size of the holding. Third, agriculture is the sole occupation of the households. Other subsidiary occupations were virtually non-existent.

Table 11 presents information on the basic socio-economic characteristics of the respondents in the area with shifting agriculture. First, over 80 percent of the sampled households have farms of less than 5.0 acres. A significant percentage of the households do not officially have any land. They are primarily agricultural labourers engaged in shifting (*jhum*) cultivation. Second, average family size tends to increase with the size of the land area cultivated. One observes that average family size in settled agriculture is considerably higher than that for shifting agriculture. The degree of inequality in the distribution of land area cultivated is significantly higher in the village with shifting cultivation compared to that with settled agriculture.

TABLE 10

**SOME SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLDS IN A FORESTED
AREA WITH SETTLED AGRICULTURE: CHITTAGONG HILL DISTRICTS 1990-91**

Farm Size (ac)	No. of samples	Average family size (no.)	Major occupation (percent)		Average cultivated area (ac)
			Agriculture	Others*	
Less than 1.0	4	7.75	100	0	0.63
1.0 - 2.5	13	7.00	100	0	1.38
2.5 - 3.5	15	9.20	93	7	2.93
3.5 and above	3	9.33	100	0	4.00
Total	35	8.23	97	3	2.19

* primarily business

TABLE 11

**SOME SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLDS IN A SHIFTING CULTIVATION
DOMINATED FORESTED VILLAGE: CHITTAGONG HILL DISTRICTS 1990-91**

Farm Size (ac)	No. of samples	Average family size (no.)	Major occupation (percent)		Average cultivated area (ac)
			Agriculture	Others*	
Landless	14	6.29	0	100	0
Less than 2.5	10	7.20	100	0	1.70
2.5 - 5.0	4	8.50	100	0	3.13
5.0 and above	3	10.33	100	0	5.00
Total	31	7.26	55	45	1.44

* primarily agricultural labour engaged in shifting ('jhum') cultivation

5.3.2 Income and employment changes since the Green Revolution

Here we consider the changes in income and employment opportunities since the introduction of the new agricultural technology. The relevant information for the two areas is set out in Tables 12 and 13. One can make the following observations:

First, production in both areas is dominated by *aus* and *boro* rice. Virtually no other crops are grown. Average output per acre does not show any significant variations across farm-size classes.

Second, annual employment in terms of man days increased for all farm-size classes after the introduction of HYVs in both villages. For the settled agriculture area, it increased by nearly 6 percent (from 268 mandays per acre to 283 mandays). While employment on small farms (of less than 1 acre) increased by more than on all other farms, in terms of actual man days they have the lowest level of employment per acre (260 man days per year as against a range of 277 to 296 days for all other classes). The information from the village with shifting agriculture shows a similar pattern even though the overall percentage increase in employment is more than double that for the settled agriculture area.

Third, in both areas the average daily income in nominal terms has shown similar levels of increase since the introduction of the new technology. However, while the incomes of households on the largest farms have quadrupled, the daily incomes of the lowest income classes have only doubled.

Fourth, in the village with settled agriculture, average annual household income has increased by 162 percent compared to nearly 250 percent in the shifting agricultural area. The increase for the marginal households (less than 1.0 acre) is 121 percent in the former area compared to over 200 percent in the latter area. By contrast, the increase in annual household income for households with the largest farms in both areas is considerably higher (over 325 percent) than those with small farms. However, if the movement in consumer price indices since the introduction of the new technology in the early 1970s is taken into account (BBS 1990), one would find that the real household income has fallen in general and much more so for the lower end of the scale, so reducing their exchange entitlements.

5.3.3 Environmental change: Trends and the current state

Over the years the environment in our survey villages has altered. In the shifting agriculture area, soil erosion has depleted soil fertility due to loss of humus level top soil. Farmers now have to apply more fertiliser to maintain yield. There is more rapid growth of weeds. However, in the settled agriculture area accumulation of humus from forests has increased soil fertility.

In both villages, application of modern inputs has reduced fish production in paddy fields by 60-75 percent following the Green Revolution. Irrigation is provided using surface and ground water. No problems seem to have been observed with ground water. Access to surface water has become more difficult however.

Table 12

Income and Employment Changes due to HYV Technology in a Forested Area with Settled Agriculture: Chittagong Hill Districts 1990-91

Farm Size (ac)	Average output per acre (maunds)		Average no. of days employed in a year			Average daily income (Tk)		Average yearly income per household (in current Taka)		
	Aus	Boro	Before HYV	After HYV	% Change	Before HYV	After HYV	Before HYV	After HYV	% Change
Less than 1.0	19.30	22.83	238	260	9.2	13.89	29.86	3750	8300	121.3
1.0 - 2.5	17.68	24.00	263	277	5.3	15.78	39.57	4158	10962	163.6
2.5 - 3.5	20.20	24.04	278	296	6.5	28.01	72.88	7789	21573	176.9
3.5 and above	19.04	22.67	273	280	2.6	23.29	96.67	6367	27067	325.1
Total	19.38	23.77	268	283	5.6	21.70	58.31	6114	16007	161.8

Table 13

Farm Size (ac)	Average output per acre (maunds)		Average no. of days employed in a year			Average daily income (Tk)		Average yearly income per household (in current Taka)		
	Aus	Boro	Before HYV	After HYV	% Change	Before HYV	After HYV	Before HYV	After HYV	% Change
Landless	-	-	224	269	20.1	12.71	37.36	3193	10061	215.1
Less than 2.5	17.22	20.22	258	273	5.8	17.98	51.72	4640	14120	204.3
2.5 - 5.0	17.44	19.78	248	285	14.9	21.21	76.23	5260	21725	313.0
5.0 and above	18.00	23.75	277	297	7.2	25.00	100.00	6930	29700	328.6
Total	17.54	21.15	243	275	13.2	16.98	53.69	4288	14776	244.6

Ecological/environmental changes include changes in micro-level temperature, colder winter of shorter duration and hotter summer, increase in air pollution, and an increase in pests and insects. Substantial decline in pasture and grazing land due to population growth, human habitation and extension of cultivation to marginal areas has led to a decrease in livestock population. The number of rice varieties cultivated following the Green Revolution has gone down. At present most farmers seem to depend two varieties, namely BR-11 and BR-6. Some varieties used in the past seem to be in the process of being lost or becoming extinct. Thus the new agricultural technology does not seem to have widened genetic diversity. If anything it may have been narrowed somewhat.

For a significant percentage of the population in the villages surveyed, forests have always been a source of fuelwood, wild fruits, honey, herbal and shrub medicine. However, in recent years, the population in these villages finds it increasingly difficult to gather these commodities because of falling supply. It takes much longer (about 2-3 times longer) now than in the past to gather the same quantity.

In both areas the number of birds and ground-dwelling animals, e.g. tigers, deer and foxes, has declined significantly due to loss of habitat and hunting. Illegal logging, human habitation and hunting have all disturbed wildlife habitat. There are insufficient forest guards. Illegal logging poses a serious problem to conservation of forestry resources. It is difficult to round up illegal loggers who may have powerful backers at political and administrative levels. Unless these activities can be minimised, prospects for conservation of forests seem bleak.

There is little prospect of expanding forestry in the survey areas. Replanting is done only on a limited scale. Limited funds and limited area available for forestry seem to be two major problems for increasing tree cover in the area. In the area of shifting cultivation the relative profitability of bamboo production (70 percent of the area) means that other trees cannot be grown.

Shifting cultivation especially on a short cycle (normally 3 years) causes soil erosion and loss of top soil. This affects the growth of forests and bamboos and results in productivity decline. Also certain types of trees affect the ecological balance and micro-environment. For instance teak and mahogany plantations allow little or no undergrowth vital for soil conservation. Furthermore some trees with broad leaves, e.g. teak, may contribute to soil erosion in heavy rain. Finally, it was gathered during the course of the survey that donor agencies have sometimes insisted on planting varieties of trees which are unsuitable for the local environment. In this case, it concerned the planting of *eucalyptus*, the seeds of which the donor had an interest in exporting.

5.4 Environmental change: Implications for sustainability of employment and development

Forests have been a source of supplementary income and sustenance for the population in our surveyed village in the Chittagong Hills for a long period of time. It seems clear that the growth of population, the depletion of natural resources, and the penetration of technological and market forces have reduced low-cost or free access to non-exchange sources of income for the poorer sections of these communities. Earlier we provided some evidence that a marginal increase in employment has followed the Green Revolution. Even

though nominal income and exchange sources have increased quite significantly, real income may have declined. Furthermore the decline in the opportunities for earning non-exchange income in order to supplement exchange income may have led to a decline in the overall quality of life while the traditional role of women and children in helping supplement family income is so undermined.

Forestry resources are being used at a faster rate than they are being replenished. This has disturbed the agro-ecological balance and wild life habitats. Thus the sustainability of some communities (e.g. tribal) may be threatened.

Employment growth seems unlikely to be sustained due to high population growth, non-existence of markets for many goods and lack of growth of non-agricultural employment. In order to increase employment and income and achieve sustainable development, population growth must be reduced and the scope of forestry-related activities must be broadened. Major obstacles in achieving this would appear to stem from problems including ethnic rivalry, cultivation practices, e.g. *jhum* cultivation, lack of cooperation between administrative departments and other factors. It was also found that illegal loggers enjoyed strong political and administrative support at almost every level.

6 Concluding Comments

In the three villages studied, the adoption of high-yielding varieties of crops and associated technology has increased the amount of labour used in agriculture at least marginally and has increased yields substantially. Therefore the amount of income available through market exchange of commodities seems to have risen. Intensification of agricultural production has occurred in all three villages along with some extension of agricultural production in the Chittagong Hill tracts. One consequence has been a fall in income available from non-exchange sources, e.g. food obtained by gathering, fishing and hunting, collecting of thatch and fuel and the availability of free fodder and sustenance for livestock. This has particularly affected the ability of the poor to earn extra income. Notably, the ability has been affected of women and children from poor households to supplement family income from such non-exchange sources. However, in the time available for gathering of primary data we were not able to determine whether or not the income of the poor from exchange plus non-exchange sources had declined and the overall changes in their economic welfare following the adoption of new agricultural technologies.

While high-yielding varieties of crops have substantially increased yields, all villages report that in order to maintain these yields, they are being forced to increase their rates of application of artificial fertilisers. This indicates problems in sustaining yields as a result of falling soil fertility and possibly also growing problems with agricultural pests. Furthermore, local varieties of crops are disappearing as farmers come to concentrate on growing just a few high yielding varieties. While this does not have immediate negative consequences for agricultural yield and employment, in the long term widely used high-yielding varieties may fail ecologically as a result of susceptibility to a particular pest, exposing a risk of serious eventual consequences for production and employment. Preservation of genetic diversity, especially of hardy local varieties of such crops could help guard against such a disaster. It is also clear that as a result of the introduction of modern agricultural technologies,

Bangladesh is becoming dependent on the use of non-renewable resources such as oil, natural gas and fertiliser; to maintain its agricultural production.

Although there has been a substantial increase in agricultural yields in Bangladesh, these have been at the expense of production in other sectors of the economy. In the Chittagong Hill Districts for example large reductions in the availability of fish were reported and also substantial reductions in Durgapur. Serious soil erosion problems and water problems were reported from the villages in the Chittagong Hill Districts, with problems also occurring in Durgapur. As a result of farming activity in the Chittagong Hill Districts, forest resources were reported to be dwindling. All such spillovers and opportunity costs need to be taken into account in quantifying the impact of new agricultural technologies on income and employment.

Crop yields in Bangladesh are still well below those of similar crops in more developed countries and Bangladesh's rate of application of agro-chemicals has, for instance, not nearly reached the levels prevailing in Japan. Possibly Bangladesh will increase its application of agro-chemicals and intensify its agriculture further along lines common in more developed countries. But further intensification of its agriculture will undoubtedly add to its environmental problems. It may be that methods of modern agriculture developed for temperate areas are not environmentally well-suited to countries located in the tropics such as Bangladesh. It seems that greater efforts should be made to adapt overseas technologies and develop new technologies which are more appropriate to the environmental and social conditions prevailing in less developed tropical countries such as Bangladesh. Much more research needs to be done to resolve these issues and to take account of environmental spillovers and their employment effects.

Environmental-employment linkages arising from technological change and production variations in agriculture in Bangladesh have been identified for the particular villages studied but, to the extent that quantification has been possible, it is mostly for on-farm or on-site effects. There is a need, apart from strengthening on-farm or on-site estimates of environmental-employment linkages and associated sustainability characteristics, to go beyond this and identify and quantify off-site effects. Such effects include production spillovers or externalities, backward and forward economic linkages and their environmental-employment effects, sustainability of production and employment taking into account all such linkages and capacities for labour absorption both in rural and urban areas. Both the overall impact of production-induced environmental change on employment and distribution require further study (Markandya 1991), including the marginalisation of women and children, and the migration from rural to urban areas.

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