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North West Regional Study (FAP-2)

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AGRICULTURE

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APPENDICES

AGRICULTURE

1. The Present Situation

1.1 Location and Climate

The North West Region's boundaries are the Brahmaputra in the east, the Ganges in the south and the Indian border in the west and north. The land slopes from north-west to south-east. The gross area is 3.4 m ha; the net cultivated area (NCA) 2.5 m ha; 0.9 m ha is taken up by water bodies and land not available for cultivation.

The region has the most extreme climate in the country. Winters, between November and mid-March, are the coolest: minimum temperatures, under the influence of the Himalayas, rapidly decrease north of Bogra but are generally lower everywhere than in the rest of Bangladesh. Conversely, immediate pre- and post-monsoon temperatures are higher. These extremes are reflected in the prevailing agricultural practices:

(a) Transplanting high-yielding varieties (HYV) of winter (boro) rice before the middle of February does not advance the harvest which begins in late May. Although January plantings usually recover from cold damage, they do not begin to develop until late February, at the same time as those transplanted in mid-February. Consequently early planting, even if there is no cold damage, increases cost of production: the crop has to be irrigated even though it is not developing.

(b) The HYV monsoon (aman) varieties suffer from partial or complete pollen sterility after the second half of October and must therefore be transplanted not later that the last 10 days of August, to flower before temperatures drop too low for good viable pollen production. Local aman is more cold resistant: it can be transplanted until late September.

(c) The region is the best suited in the entire country for wheat: it was in the North-West that HYV wheat production begun on a large scale in the early 1970's.

Precipitation increases from west to east and south to north from about 1,500 mm to 2,000 mm. In most years rainfall is adequate and of sufficiently long duration to ensure a reliable transplanted aman rice crop, be it HYV or local. However, farmers are increasingly using the irrigation facilities installed for the boro and t. aus (early monsoon) rice (Section 1.4) for t. aman in years and periods of insufficient rainfall. 1992 was such a year.

1.2 Topography and Soils

There are three major topographic regions: (1) the floodplains of the major rivers; (2) the Himalayan Piedmont; and (3) the Barind tract. The Piedmont and the Barind are higher than the floodplains and therefore suffer only minor flooding, and that mostly from drainage congestion. However, runoff from these areas contributes to the damaging excess of water in the floodplains.

Appendix 1, Physiographic Units of the Floodplains, describes the physiographic units of the country. The floodplains are those of the Brahmaputra, the Teesta along its present and earlier courses, and the Ganges. The Teesta floodplains subdivide into the catchments of several rivers, each now following one of the Teesta's former channels.

There are minor differences in the soils: the most notable is that the Gangetic plains are rich in lime while the others are not. However, soil conditions are suitable everywhere to grow all the crops commonly cultivated in the country. Differences in their proportion, other than those constrained by winter temperatures and flood levels during the monsoon, reflect local demand, generated by established marketing channels for specific crops. A good example is the concentration of tobacco in the Rangpur area on the Teesta floodplain. However, it would appear that the area of HYV boro rice is increasing at the expense of tobacco under the combined influence of market conditions and the spread of irrigation. Similarly, the Pabna area, being closest to the river port of Nagarbari, has a large area of field vegetables, which are marketed in Dhaka and Chittagong, because of the ready accessibility of cheap river transport.

Micro-elevations, because of the risk of excess water from rainfall or the rivers, exert a major influence on agricultural development. These are referred to as F for flood levels, and are grouped by the Master Planning Organisation (MPO) as follows (m):

F0: 0-0.3; F1: 0.3-0.9; F2: 0.9-1.8; F3: 1.8-3.6; F4: 3.6<

Not unexpectedly, the cropping sequences adopted by the farmers for each elevation are clearly identifiable. As far as possible, farmers want to operate land in three of the four categories: areas that at any time flood to F4 levels have only a limited cropping potential and are mostly used for fisheries.

1.3 Crops of the Region

Cropping intensity, the percentage of the cultivated area of the floodplains actually cropped each year, was found to be 158%, a very similar figure recorded by BBS. The kinds planted are either broadcast (b) or transplanted (t); either local (l) or HYV. The nomenclature used with the prefixes mentioned is boro for rice planted before March 15th; aus until June 1st, and aman after that date. The exception is b. aman, which is planted in early April.

By now almost the entire area of boro is HYV. Local varieties are only grown in low-lying areas that would flood too early for HYV to be successful, or where the water levels are too high for HYV boro. In case of t aman there is still some deliberate decision not to grow HYV in all locations where the water levels would permit it. The HYVs, to be fully successful, demand more inputs, planting has to be completed earlier than with the local varieties and are said to be inferior in taste. However, the taste preference for local varieties is diminishing, as it has in all countries where HYVs, wheat or rice, have been introduced. It can therefore be safely predicted that HYV t aman will, in the not too distant future, occupy as much land as the farmers' other resources and the timing and extent of monsoon flooding of his land will allow. This process will be further accelerated by the recently released photo-sensitive HYVs: BR 22 and 23, which will flower with diminishing daylight, and not a set time after planting, thereby to a large extent overcoming the danger of pollen sterility (Section 1.1 b).

Other crops in descending order of importance as far as the area they occupy is concerned are wheat, jute, oilseeds (mainly Brassicas and sesamum) sugarcane, pulses, vegetables and spices. All the other crops take up 8% of the cropped area. (Table 1.1)

Table 1.1 Agriculture in the North West Region in Numbers

Gross area : 3.4(m ha) Cultivable area: 2.5 m ha
Area flooded to different levels (m ha):

F0: 0-30 cm	1.3	F1: 30-90 cm	0.8
F2: 90-180cm	0.2	F3,4 & 5:180cm	0.1

Name of Crop	%	Yield t/ha	Name of Crop	%	Yield t/ha
Rice: HYV boro	26	5.0	Wheat	8	2.7
t.aus	6	4.0	Jute	7	1.8
t.aman	28	4.0	Oilseeds	6	0.6
Local boro b. aus	1	2.5	Sugarcane	5	47.5
l.t.aman	20	1.3	Pulses	3	0.8
aus/aman	28	2.3	Vegetables	2	NA
b. aman	5	1.8	Others	8	NA
	5	1.7			
Rice	119%		Others	38%	Total 158%

Notes: (i) Source: Bangladesh Bureau of Statistics (BBS) and MPO.

(ii) Sugarcane yield is the average between plant and ratoon crop. For a detailed description of the region's crops see Appendix 2, Crops of the Region.

1.4 Irrigation Development.

A most significant development of the last ten years or so has been the almost exponential expansion of rabi irrigation: the irrigated area has just about quadrupled. On land free of floodwaters by January and not again flooded until June the farmer has the choice to grow b aman, mixed aus/aman (if by July flood levels are not so high as to destroy the aus portion), or boro, which cannot be followed by either of the crops mentioned. The yields given in Table 1.1 readily explain why they prefer to grow boro. The other rice crops, apart from the lower yield, are at much greater risk from flood damage. Planting a short-term rabi crop in November, which would mean delaying the planting of boro till late February or early March, may entail some risk if the floodwaters rise before mid-June. There is no such risk when double cropping with b. aman: the rabi crops following it, - pulses, oilseeds or wheat, - are off the land by late March, so that mixed aus/aman or b. aman can again be sown. The usually minor flooding in June is positively helpful for the better development of mixed aus/aman and b aman. Nevertheless farmers will grow boro in preference to the b aman-rabi sequence; a glance at the yields in Table 1.1 readily explaint the reason behind this choice. Furthermore, in most part of the region flooding does not exceed the critical 70 cm level until well into the second "decad" of June (June 11-20) and therefore an early rabi crop can usually be safely grown before boro. The land is then left vacant until November, when the rabi crop is planted (Appendix 4, Cropping Pattern Calculations).

A major, relatively recent but rapidly spreading development is the increasing extent to which irrigation is taken for granted for the t amans. While not needed in most years, farmers are increasingly irrigating during dry spells or the early cessation of rains. This can become a significant factor in evening out t aman yields which, especially in the southern and western part of the region can be diminished in years when the rains cease early or indeed almost fail, as they did in 1992.

When considering irrigation in assessing the expected development scenario it was assumed that the extend of present irrigation equals the area of boro. While a slight simplification, it has been established that almost without exception boro takes up so much of the actually irrigated area that the generalisation can safely be made. As far as the future irrigated area is concerned, the method of investigation followed is described in Volume 10, Hydrology and Groundwater. For planning purposes the expected development until 2007 was taken.

1.5 Input Use

Bangladesh uses about 1.6 m tonnes of urea (46% N), triple super-phosphate (TSP, 46% P2O5) and muriate of potash (M/P, 60% K2O). Small quantities of lower-analysis fertilisers are also used, like ammonium sulphate (21% N) and single superphospate (SSP, 16% P2O5). Fertiliser use in Bangladesh as a whole is about 50kg/ha nutrients. There has been a 16-fold increase since Liberation. Fertilisers are applied to all the more productive crops: boro rice, t. aman, local or HYV, sugarcane if grown on flood-free land where yield expectations are around 50 t/ha (Appendix 2, Crops of the Region) and the small area of irrigated wheat. The high-value crops: potatoes, vegetables, spices and orchards usually receive generous doses of fertiliser. Broadcast aus and aman get small amounts of nitrogen, to help their better establishment. The blends of nitrogen, phosphate and potash applied are mostly in line with recommendations by the Agricultural Extension Services, except that the mixtures applied to crops receiving lower doses tend to be higher in nitrogen or are only urea. This practice is in line with what farmers do the world over. Fertilizer mixes for all the common crops usually contain gypsum to combat sulphur deficiency which is an increasingly recognised problem. They should also contain zinc sulphate, at the rate of about 10-15 kg/ha. Their cost has been included in the fertilizer prices used for economic analysis.

Approximate doses of nitrogen, phosphate and potash (NPK) applied to the major crops are in Table 1.2.

Table 1.2 Approximate Present Fertilizer Application Rates (kg/ha)

	N	P_2O_5	K20
HYV Boro rice	120	60	35
T. Aman	90	45	30
Local boro	40	20	10
T. Aman	35	15	10
Floating rice	25	0	0
Wheat	35	20	15
Mustard	25	0	0
Sugarcane	90	40	60

Source: District Agricultural Staff and Farmer Interviews.

Pesticides, mostly insecticides, are regularly applied to rice, particularly boro and transplanted aman, local or HYV. Both granular and liquid formulations are used. Aerial spraying, common at one time, is by now much reduced and in line with modern pest management practices, initiated by the Agricultural Extension Services. An interesting local pest control practice is to provide perches for insect-eating birds in rice fields, thereby encouraging their access to the growing crop in an otherwise largely treeless countryside. The perches are duly removed when the crop ripens.

2. The FAP 2 Agricultural Investigations.

2.1 Statistics and Studies

There is much statistical information on all aspects of agriculture from BBS and MPO. The data pertain to the smallest administrative unit, the thana (upazila). Thana boundaries are not necessarily identical with the areas in need of flood protection. It would not be practical if they were: all farmers need land at all levels, to ensure crops in dry years, -the low-lying areas,- and the ones when floods are above average, the highlands. Therefore the BBS data as compiled can only be taken as indicators of the situation in the smaller potential flood control and drainage (FCD) areas (Appendix 4, Cropping Pattern Calculations).

A wealth of knowledge on all aspects of agriculture in the region, recorded or obligingly provided in the course of discussions, exists in the research and extension organisations: the Bangladesh Rice Research Institute (BRRI), the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE). The assistance of their officers is hereby gratefully acknowledged.

Many agricultural sector studies have been conducted since 1971, and even earlier. Summaries of all have been perused; many of them have been studied in detail. Development trends since Liberation have been noted in the field and from records, to establish a base from which future trends can be estimated.

The FAP 12 investigations, designed to be a source of data for the regional studies, have determined the effects of earlier flood control, drainage and irrigation (FCD/I) projects. Their findings are discussed in Section 4.2.

2.2 Field Investigations

2.2.1 General Surveys

Fieldwork included a survey of the floodplains in the course of which 423 farmers have been interviewed (Appendix 3, Surveys and Studies). In addition, a detailed socio-economic survey has been conducted in the Gaibandha area (Volume 5). Multidisciplinary teams visited upazilas in the proposed project areas and have collected pertinent information from farmers and officials. Agriculturists have recorded farmers' responses to flooding and the summer and winter cropping sequences followed under their specific conditions. From this information their likely reaction and utilisation of an improved water regime, brought about by an FCD project, was extrapolated. Much attention was paid to rationalise and pin down

to flood depths and their time the reason why farmers elect to grow certain crops on specific parts of the landscape. This information was then used to identify water levels at different "decads" of months, which is major determining factor in crop selection.

It should be noted however that the decision as to which crops to grow does not depend only on the depth and time of flooding. They are influenced by rainfall because of its late start, early finish or possibly inadequate total which may not allow two rice crops to be grown in the monsoon in areas where supplementary irrigation cannot be provided. Economic and management reasons also play a part. These are personal and judgemental factors that cannot be defined in terms of agronomy and water depth. Therefore at this point a degree of judgement, based on local knowledge, has been used. Details of the process, and its rationale are described in Appendix 4, Cropping Pattern Calculations.

2.2.2 Livestock and Draft Power.

The livestock situation has been studied primarily in connexion with the availability of draft power at present and in the expected future with-project situation. It was noted that draft power in relation to the growing work load is diminishing, both as regards the number and strength of animals available per hectare of cultivated land. Land traditionally ploughed and laddered (a form of harrowing) four, five or even six times in preparation for a transplanted rice crop is now only ploughed and laddered perhaps three times. Shortage of draft power may well delay the full exploitation of improved conditions expected from FCD projects. The availabitity of cattle feed is not likely to increase substantially: increased fodder production could only take place at the expense of human food production. Addressing this issue, and suggesting or rationalising remedies, is not part of FAP studies. It must, however, be noted that the only apparent solution is increasing mechanisation, which is making an encouraging start.

On the other hand small stock and poultry, as also noted by the FAP 12 studies, increase with the availability of more grain from threshing floors and the better utilisation of crop residues. This issue is more fully developed in Appendix 3, Surveys and Studies.

2.2.3 Agro-Forestry

The present situation regarding fodder and fuel trees has been examined. Like animal husbandry, addressing the obvious shortage of any form of tree cover is not part of the FAP studies, except to note that the improved environment will increase suitable areas for tree planting. Trees like Leucaena leucocephala, (ipil-ipil), already common in roadside plantations and used for fodder by stock owners living near such roads, could readily be grown on field boundaries that will be dry for a longer period, without impinging on arable crop production.

An interesting feature is the extent to which Sesbania sesban (doncha) is being grown. It is dried and used for fuel, mostly by the grower. If sold, it fetches about Tk 1,000 per bhiga, Tk 7,500 per ha; the buyer does the harvesting. In some cases it is taking the place of b aus on high patches where b aus would be a risky crop because of the permeable nature of the soil. It is also grown on field boundaries.

2.2.4 Labour

It soon became clear that labour availability for peak demand periods (harvesting boro and aman rice and also transplanting aman) has to be considered. Even today farmers rely heavily on labour migrating from other parts of the country for seasonal work. The question inevitably arises whether this source of labour will remain adequate when demand increases. The possibility of increasing employment opportunities in the home areas of the migrant workers cannot be ignored: Flood Control and Irrigation (FCD/I) projects are expected to be initiated in all parts of the country, creating more employment opportunities nearer their homes.

3. Potential Areas for Flood Control and Drainage

3.1 Definition and Extent

The cultivated area of the floodplains, the potential FCD area, is given in Table 3.1

Table 3.1 Cultivated Area of the Flood Plains (m ha)

Teesta (along its old and present course)	1.03
Karatoya-Bangali	0.26
Lower Atrai	0.08
Active Brahmaputra	0.14
Lower Purnabhaba	0.13
Gangetic Floodplain	0.80
Total gross area:	2.44
of which cultivable:	1.63

Source: Land Resources Appraisal of Bangladesh For Agricul-tural Development; Report 2; Agroecological Regions of Bangladesh; UNDP/FAO, 1988.

3.2 Crops and Farming Systems on the Floodplains

On the floodplains the proportion of rice to other crops is higher than in the region overall. In the monsoon there is less land that is not covered by water and the proportion of F0 land (Section 1.2) is also lower. Inundation, while in moderation an advantage for rice, severely restricts the cultivation of other crops as witnessed by the fact that sugarcane in flooded areas yields only about half that in flood-free areas. Jute will do better if inundation does not come before August. However, rice is the preferred choice (Table 1.1). Jute at present occupies only 7% of the cropped area and is likely to diminish further: its future market prospects are generally not regarded as hopeful. During our studies in 1991-92 farmers experienced some trouble in selling their production at reasonable prices.

Irrigation water from surface sources is relatively easily accessible in the rabi from ponds and beels left behind by floods. Near these, and also where the groundwater is shallow, boro rice has always been grown, at first irrigated with the many ingenious traditional water lifting devices and lately with low-lift pumps. Groundwater is usually readily accessible for shallow tubewells or open wells. These conditions have increasingly induced farmers to switch to boro.

The foregoing do not mean to imply that rice is the only crop grown, summer or winter. Irrigation, while widespread and still expanding, is unlikely to cover more than 70-80% of the potentially irrigable area. The reason for this is the groundwater potential, institutional and personal constraints of the operators and the high cost of deep tubewells which are needed if the irrigated area is so large as to lower the groundwater level below the suction capacity of the centrifugal pumps used towards the end of the dry season even when placed some way down a well (Volume 10, Hydrology and Groundwater). In places where there are no irrigation facilities a number of non-rice rabi crops are, and always will be, grown.

Depending on the expected time of the floods returning, these are pulses, oilseeds, (mainly Brassicas and sesamum) and wheat; also sugarcane for jaggery (gur) production, to sell as chewing cane, for local juice extraction and for the many sugar mills. The problem with wheat is that the land is not available until *April for replanting which may be too near the arrival of floods for either of the broadcast monsoon rice* crops to establish themselves.

Farmers operating in flooded areas endeavor to farm also at higher elevations: flood-free land is necessary for survival in exceptionally wet years when the species planted, b. aman, would be damaged or destroyed. They will go long distances from their homesteads to cultivate such areas. Numerous studies, including the FAP-2 survey, noted that the average farmer cultivates not less than 4 or 5 plots, all at different micro-elevations: the reason for this apparent labour-wasting fragmentation is readily seen when the risks to basic food crops at the different flood levels is assessed. For details on the region's crops see Appendix 2, Crops of the North-West Region.

4. Expected Agricultural Development with FCD projects

4.1 The Nature of Likely Project Benefits

The FCD projects would enable a change to more productive crops (from b. to t. aman, be it local or HYV) and reduce the risk of flood damage to the crops normally grown. Cropping intensities however, may in some cases be reduced, for instance if flood protection allows a farmer to grow boro, he may well do so instead of the b aman followed by a rabi crop, which he is now forced to do. While, strictly speaking, this reduces cropping intensity on that piece of land from 200% to 100%, it actually increases production from 1,7 t/ha of b aman plus 0.6 or 0.8 t/ha of oilseeds or pulses to 5 t/ha of boro (Table 1.1). In the following sections the likely changes in cropping patterns based on the expected with-project water regime are analysed and the farmers' reaction to these changes projected. Yield improvements, apart from the prevention or reduction of losses through damage by floodwaters, cannot be attributed to FCD projects: they have no crop husbandry improvement component. Such yield improvements that are likely to occur will be due to improvements in crop varieties and possibly better farming practices; it must however be stated that within the given means farming practices in Bangladesh are as good as anywhere. The foregoing are also the findings of the FAP 12 studies, which reviewed 17 FCD and FCD/I projects, of which six were in the North West Region.

Any change in the risk factor, i.e. the likelihood of partial or complete loss of crops is discussed in Volume 13, Economics.

4.2 Findings of the FAP-12 Studies

The principal country-wide findings of the FAP-12 studies are as follows:

(a) Cropping intensities, especially the area under rice, have been increased by FCD. However, the caveat made in Section 4.1 was also identified by the FAP 12 studies. The FCD projects have strengthened the dominance of rice in the cropping system but had a mostly negative effect on diversification.

(b) Farmers exploited the changes in the water regime by switching from mixed aus/aman to t. aman and from local to HYV t. aman. A less spectacular, but nevertheless significant change was from b aman to mixed aus/aman: for the loss of 3-400 kg/ha of b aman they gained about 1.3-1.5 t/ha of aus, at a time of the year when grain tends to be in short supply.

(c) The area of boro has increased, as has the proportion of HYV to local varieties. In the North-West by now the area of local boro is but a small fraction of the total, usually confined to depressions. The change is far more signifant in other regions where flooding comes earlier than in the North-West: in the North-West significant flooding is rare before the boro is harvested in late May or early June. In many cases everywhere, and in the North-West in particular, the increase in the boro area is attributable to the growth of irrigation (Section 1.4). In general FCD has not brought about a significant expansion in irrigation unless the project included a component to promote it, or it gave a degree of protection to areas that encouraged farmers to install irrigation systems using their own resources. In the region only two of the six projects evaluated showed significant boro intensification, and even there the share of FCD was considered to be minor. These were the two BRE transects, Kazipur and Kamarjani. Expansion of the boro area has come about because of the drying up of beels which could now be planted to boro and, to a lesser extent, because of protection from early flooding from the Brahmaputra, about the only physiographic unit in the region where this risk exists.

(d) Production per unit area has increased because of the change to HYVs from local varieties, not from increased input use. It might have been expected that the reduction in flood damage risks would induce farmers to use more fertilizers and pest control chemicals. This does not appear to have happened yet: it seems that confidence that flooding has indeed been alleviated is yet to be built up. It is also likely that fertilizer application rates are already near the optimum for crops that are fertilized under the prevailing cultural practices and given the genetic potential of the varieties in use. This applies particularly to crops other than rice and vegetables.

(e) The issue of soil fertility has been examined. If fertility is measured by the amount of nitrogen fixed by the blue-green algae, then the decrease of their concentration brought about by FCD projects has been reduced. On the other hand the phosphates, potash, sulphur and micronutrients in the parent material of the soil become more readily available as water relations and soil aeration improve. The changed soil-water relations enable better use to be made of chemical fertilisers applied, and undoubtedly will continue to be applied in increasing quantities by commercial farmers who produce the bulk of the food consumed by Bangaldesh's, -and the world's, - expanding population. Therefore crop husbandry practices have moved nearer to those in developed countries where increasing reliance is made on chemical rather than biological means to maintain productivity. This trend will undoubtedly increase as farmers gain confidence that the FCD measures do in fact work and warrant heavier investments in inputs. With population densities increasing world-wide, there is little alternative to increased fertiliser use. The only alleviation is to regulate fertiliser doses in accordance with their uptake by the plants. To some extent this is already done in Bangladesh: the amounts used and recommended, and likely to be used in the future, do not exceed these limits.

(f) FAP 12 has highlighted the likely problem of drying the increased harvest. Drying facilities: suitable surfaces on which safely to spread out the grain to dry, and ensuring the means of rapid protection in case it rains, is a perennial issue in Bangladesh. The problem will be exacerbated with increasing quantities to be dried, especially that harvested in the rainy season. While not within the terms of reference of the FAP investigations, addressing this issue cannot be postponed much longer (Appendix 3, Surveys and Studies).

(g) The issue of broadcast HYV aus has been flagged. It was found that, despite the established fact that transplanting these varieties gives a better yield, in many places it had to be broadcast because of restricted nursery facilities. Fortunately this does not appear to be an issue in the North-West region: professional nursery growers produce increasing quantities of seedlings of good quality and their market is expanding (Appendix 3, Surveys and Studies).

(h) The studies and the survey carried out by FAP 2 has found that in most project areas the number of cattle has decreased. While the amount of crop residues available for stock (rice straw and the increased amount of rice bran from the local husking mills) has increased, this may have been largely cancelled out by the loss of seasonal grazing: former seasonally inundated lands, the traditional common grazing areas, became cultivable due to the projects. The increase in irrigation also exchanges rabi stubble grazing with boro. Therefore the reduction in fodder quality and cattle numbers can be attributed as much to the increase of irrigation as to FCD. Furthermore, the straw of HYVs is less palatable than that of the local varieties and also possibly less digestible. Consequently, available draft power and milk supplies have declined. On the other hand the number of sheep, goats and poultry has increased. To what extent the two factors compensate is difficult to assess (Section 2.2).

(i) The studies have noted that supplementing rice straw with a urea-molasses mix to enhance its nutritive value has not been exploited. They, and also the FAP 2 investigations, found that while several people knew of the method, none have actually pratised it. Seemingly there have been some inevitable mishaps when used. While the introduction of this mix requires care and attention to detail, it is being practised in many places with good results. It would appear to be an easy means to enhance the performance of draft animals if urea-molasses feed supplements were to be further pursued: both are readily available in Bangladesh.

The overall conclusion has to be that FCD has made no impact on livestock production. Crop residues will be an increasingly important stockfeed, but they will also be used, as at present, for thatching, and, especially the straw of b. aman which is the least palatable, for fuel, Thus, although the total volume produced will increase, this increase is unlikely to be reflected in increased livestock production.

There is some evidence, as manifested by a steady expansion of strawboard production in Bangladesh, - some even for export, - that there may be an industrial market for straw in areas that have a ready access to cheap river transport. Nevertheless, it may be prudent at this stage to omit the increased value of crop residues from crop budget calculations.

4.3 The Development Scenario.

4.3.1 Crop Selection

In envisaging likely future development on land now affected by high seasonal water levels, the following assumptions can be made, based on the farming systems seen to be evolving in areas not affected by floods:

(a) Irrigation development is likely to continue to its limit in areas free of flooding in the boro rice season where groundwater is available. "Available" has to be qualified: with technologies currently used it means by suction, i.e. surface-placed shallow tubewells (STW) or, at best, centrifugal pumps sunk in a pit: deep-set smallow tubewells (DSTW). However, even with the present high cost of deep tubewells (DTW), there is a steady conversion from STWs and DSTWs to DTWs. Bearing in mind past developments, the replacement of the realitvely cheap low-lift pumps (LLP) by SWTs which has brought about the present expansion in irrigation, it does not seem unlikely that suitably sized DTWs will bring about a similar expansion. There do not appear to be restriction on exploitable groundwater in the floodplains, only on the method of its extraction (Volume 10, Hydrology and Groundwater).

(b) Once irrigation is available, it is increasingly used on HYV and l t aman at times when there is water stress. This situation has arisen in a small way in 1991 and much more strongly in 1992, an exceptionally dry year. However, it occurs quite regularly in October and early November, a critical time of pollination and grain filling, especially in the western part of the region. Having irrigation available when needed will ensure a full yield of t aman in dry as well as "normal" years.

(c) There is strong evidence that farmers wish to grow transplanted rice if possible. This trend has brought about the practice, introduced and developed by the farmers, of transplanting floating rice, a species traditionally broadcast (the b. aman). Yields when transplanted are reported by some to be higher than when broadcast, but even if they are the same the advantages are that it can follow boro, enabling two crops to be grown if water levels permit it. Broadcasting floating rice after the boro is harvested cannot be done before June which does not give it enough time to develop sufficiently by late July to withstand the deep flooding that can be expected. 1992 was an exceptional year in that the floods were much delayed and when they came, were relatively slow in rising and not very deep. Several farmers broadcast deep-water rice in their boro stubbles, and appeared to have been successful. However, they were emphatic that this practice has a less than one-in-ten chance of success. If however fairly mature seedlings are transplanted in June, they will have reached the stage by late July to be able to expand with rising water levels. Farmers also maintain that labour requirements of transplanting are lower than the cost of weeding the broadcast crop, which in April and May is a most laborious operation.

(d) Other crops grown in flood-affected areas are jute and sugarcane. Both can tolerate considerable depths of water after about mid-July, although the yield of sugarcane is much lower under such conditions than if grown on land that is flood free: 20-25 t/ha rather than 45-50 t/ha. Jute and sugarcane are grown on non-irrigated land: when

10%

irrigation becomes available, and the soil not too permeable, farmers switch to boro which cannot be followed by jute. Sugarcane in Bangladesh is a biennial, not compatible with any annual crop. However, because except on the Gangetic plains it is usually grown on the lighter soils where boro would require large quantities of irrigation water, farmers advise that even with flood control most of the sugarcane area would remain.

(e) Shortage of draft power has been reported by many farmers (Section 2.2.2). This may make a rapid change-over between boro and TDW aman, or mustard and pulses to boro, difficult. Mustard and pulses planted in November mature in late January to early February: the next crop has to be planted within about two weeks to escape flood damage. Shortage of draft power is gradually being overcome by the increasing use of two-wheel tractors. At present the quality of land preparation, because the implements used are unsuitable, is not perceived by farmers to be as good as with animal-drawn implements. The technology to equal and even better the quality of land preparation over that done with the bar-point plough and ladder is well known and practised in many countries. It is merely waiting to be introduced to Bangladesh, which is certain to happen with properly directed adaptive research.

(f) There is evidence of labour shortage in most areas, overcome by the use of migrant labour (Section 2.2.4). While by no means certain, it is assumed that this can continue in the future.

The points discussed above are further developed in Appendix 2, Crops of the Region and Appendix 3, Surveys and Studies.

4.3.2 Utilising the Landscape.

With the widespread adoption of the shorter-statured HYV rice varieties, farmers are determining their cropping pattern on slightly different criteria than those set out in the standard MPO flood levels (Section 1.2). Also, while flood levels from which protection is required is a matter of engineering design, from a crop production point the time when the water levels rise above certain points is at least as important as its ultimate depth. Therefore the farmers, bearing in mind the increasing importance of the short-statured HYVs, determine which crop to grow in what flood depth according to the following water levels and timings:

(a) No rice can be transplanted or broadcast where water levels rise much above 30 cm for 6-8 weeks.

(b) HYVs, boro aus or t aman can only be grown where water levels do not rise above 70 cm by the time the plant is fully grown and the panicle has emerged, and stay at that level only for short periods. 70 cm inundation for more than a few days does not kill the crop but interferes with photosynthesis through the prolonged submergence of the flagleaf and therefore reduce yields.

(c) The same principle applies to l t aman or aus. However, because they are taller, the limit is 1 m. Thus, l t aman can be grown where HYV t aman would thrive, but not the other way round.

(d) Jute will thrive in land flooded to about 1.50 m after the end of July, where b aus would be submerged. Therefore while jute can be grown under conditions where b aus cannot, b aus would not thrive where jute would successfully survive. The same applies to sugarcane (Section 4).

(e) For DTW aman water levels must remain below 30 cm for 35-40 days after transplanting because it takes that long for the seedlings to be able to expand with rising water levels. Floating rice, whether broadcast in March or transplanted in June, does not yield well where the flood levels rise much above 3 m and are only grown in such places if there is no alternative. The 3m point is therefore perceived as the limit of land that can be profitably used for agriculture in the flood season.

For further details on integrating the different crops into a cropping pattern see Appendix 4, Cropping Pattern Calculations.

5. Expected Future Cropping Patterns

5.1 The Farmers' Criteria for Selecting Cropping Patterns

5.1.1 Irrigation

Judging from past developments it is expected that eventually most of the land suitable for HYV boro will be growing it: except for Physiographic Unit no 6, the Active Brahmaputra Floodplain. This Unit, if it were to remain unprotected, would flood before the boro matures in most years. Boro rice will then become an even more important rabi crop than it is at present, with or without FCD projects. Information on historic irrigation development and its potential under different irrigation modes, has been compiled for each project area. There is little reason to suppose that availability of, and access to, groundwater will be a serious constraint (Volume 10, Hydrology and Groundwater).

5.1.2 Rabi Crops

No crop approximates HYV boro in the amount of food produced per unit area; few, and all with only limited market potential, exceed it in profitability (potatoes, vegetables, spices). Therefore it is unlikely that there will be extensive areas of other rabi crops where there are irrigation facilities.

5.1.3 Monsoon Crops

In the monsoon season the major crop will undoubtedly be rice. The farmers' preference is for HYV or local t. aman. On present trends it would appear that the area of transplanted floating rice will increase, thereby enabling double cropping on land flooded beyond 30 cm after late July. However, it must be recognised that there is a management issue that may hinder its eventual area: land preparation and transplanting must take place at the same time as the boro crop is to be secured. Securing a crop already grown always takes priority over one yet to be planted.

5.1.4 Diversification.

There is no evidence that there will be an increase either in jute or sugarcane. While jute is easy to grow, its harvest and processing is time-consuming. It cannot follow boro rice and it is difficult, with the olitorius species almost impossible, to follow it with t aman of either kind. It is likely to remain the crop for the non-irrigators, on out-of-command patches within irrigated tracts, where it is not possible to grow boro or on land that floods too soon, and too deeply, for boro (Section 4.3.2).

In most parts of the region floodwaters do not rise until early June, although in some places they do not recede until well into November. Where they do recede by early November, it is possible to plant mustard or pulses, which are quick-maturing short-term crops, and follow it with late boro or early transplanted aus. The difficulty with this sequence is that boro or early aus must be planted quickly if it is to escape flooding in exposed places. The rapid changeover may not be possible with the labour and land preparation resources available to the average farmer and therefore this practice, while agronomically feasible, may be constrained.

5.1.5 Triple Cropping.

The issue of growing three crops in a year, or five crops in two years, is often raised. Given suitable water levels, there is no agronomic reason against it: a number of such cropping patterns are being practised on a small scale. The following have been observed:

(a) With water not rising above 70 or 100 cm before late September, boro followed by local transplanted aus, (to shorten the time it occupies the land), followed by HYV or local t. aman, [depending whether the depth of water is 70 cm or 1 m; Section 4.3 (b) and (c)] and again by HYV boro.

(b) A variation of the above is HYV boro followed by HYV t aus in June, followed by l t aman in early September.

It is however most important to note that all the informants who followed one or the other of these sequences eithr owned draft animals or a two-wheel tractor: they did not have to rent either of them.

(c) HYV t. aman followed by mustard or pulses, followed by HYV boro and again HYV t. aman.

(d) HYV boro followed by early HYV t. aman (a fixed-period variety) followed by wheat. In the following year wheat is followed by HYV t. aus, which would make the aman crop so late that wheat could not follow it and therefore the next crop would be HYV boro. This sequence gives five crops in two years.

While any of the above, and several more, are feasible, in each case harvest must be followed immediately by land preparation and planting which must take precedence over, or be carried out simultaneously with, securing the already harvested crop. No farmer would willingly divert labour from securing a crop already grown, especially in seasons when there is risk of rain damage. Also, draft power must be readily available, which can by no means be taken for granted (Section 2.2). It is therefore concluded that triple cropping is unrealistic on a large scale.

5.2 Future Cropping Patterns

The future-without and future-with project cropping patterns are based on land capability and the farmers' expected reaction to the flooding situation. The guiding principles are as follows:

(a) farmers with irrigation facilities will grow HYV boro on all land that is flood-free between February and the 10th June;

(b) all, irrigators and non-irrigators alike, are assumed to grow HYV t aman on all land where it can be grown because of the water levels and l t aman where they rise slightly higher;

(c) TDW aman would be grown on land that does not flood above 30 cm until late July and never floods above 3 m;

(d) a short-term rabi crop [one of the common Brassicas (rai or tori), safflower or a pulse] would be grown on land that is flood-free by early November and still be followed by boro or early HYV t. aus;

(e) Land that is flood free in early November but floods again before May cannot be used for boro but is suitable for wheat; its growing season is from mid-November to late March.

Without irrigation it is not possible to grow boro. On such areas the calculated crop mix would consist of all the other rice crops:

(a) broadcast local aus on land that does not flood above 1m level before late July;

(b) b. aman on land that floods deeply by about July;

(c) mixed aus/aman on land that does not flood deeply until early August and therefore it is possible safely to harvest the aus portion;

(d) l t aman, planted in July on land that does not flood above 30 cm until early September; HYV t. aman on land that does not flood above 30 cm until late September;

(e) rabi crops on unirrigated land are not constrained by the needs of boro. Under such conditions wheat as well as pulses and oil crops are grown, usually on residual moisture;

(f) late rabi crops are the minor cereals, the Setaria and Panicum millets (kaun and chena).

5.2.1 Forecasting Cropping Patterns

Different methods of forecasting cropping patterns in the [FWO] and "future with"situation have been used,depending on whether the planning was at regional (pre-feasibility) or project (feasibility) level. In both cases attempts were made to make use of the improved accuracy of predicting water levels which

can be provided by the hydrodynamic model. However experience from the work carried out prior to the interim report indicated that there are still many difficulties to be overcome before model-based predictions of cropping patterns can be used with confidence. These include:

- the accuracy of the model, in relation both to topography, water levels and discharges;
- problems of scale and micro-topography, which may conceal significant differences in flood depths and durations over small areas.

5.2.2 Cropping Patterns for Regional Planning

In this case a modified version of the MPO method was used, based primarily on F levels and published BBS statistics. The method developed by MPO (now WARPO) involved, first, developing representative cropping patterns for land classified according to its flooding characteristics, and second, making assumptions about the shifts in flood phasing that would occur under with-project conditions. It was assumed that, when land was transformed to a different flood phase (e.g. from F2 to F1 land), it would take on the cropping pattern associated with the new flood phase.

This approach is appropriate for pre-feasibility level planning and has generally been followed in this study for regional planning analyses, but the approach has been modified in a way that should more accurately describe the expected transitions with-project.

Modifications have been made in at least two major respects:

(a) Cropping patterns on particular flood phases have been determined by allocating individual cropped areas to specific flood phases according to some basic rules discussed below. In this exercise the present-condition flood phasing for a particular project area was derived from MPO (WARPO) data, while the present-condition areas of individual crops were derived from BBS 1989 statistics, the most recent available.

(b) The shift in flood phasing resulting under with-project conditions was derived, partly by using the FAP 2 model analysis and drainage analysis, and partly by applying judgement based on knowledge of the project areas and other sources such as FAP 12 studies. This approach allows for variations in the degree of transition between project area, whereas the MPO approach (described in MPO Technical Report No 26, March 1987), assumes a standard pattern of change for FCD projects, as follows:

(i) Irrigated land:	-	100% F1 to F0
		75% F2 to F0
		25% F2 to F1
		20% F3 to F1
		45% F3 to F2
		35% F3 remains F3.
(ii) Non-irrigated land:	-	100% to F0.

In some project areas, these assumed transitions are likely to overestimate the changes that are feasible.

In this analysis the MPO flood phase data and BBS data were both at thana level. In projects where only a portion of the thana fell within the project boundary, it was not always appropriate to assume that the thana-level flood phase distribution would apply within the project area. This is the case, for example, in the Bogra Polders, where thanas such as Adamdighi and Nandigram have a high proportion of F0-F1 land, but where the parts of these thanas falling inside the project areas were mostly F2-F4 land. It was generally not difficult to work out where such adjustments were needed.

The initial stage in deriving cropping patterns, then, was to match MPO flood phase data with BBS crop statistics. The following rules were used:

(a) The total irrigated area was assumed equal to the area of HYV boro + HYV aus (a cross-check was made with irrigated areas derived from the 1989 AST survey, and generally there was a good correspondence). The irrigated area was then allocated to different flood phases using the general principle that the proportion of irrigated land in a particular flood phase is generally higher on more low-lying areas (i.e. the highest densities were on F3 land, followed by F2 land etc.). This assumption is based on the historical experience of irrigation development using STWs, particularly in the Lower Atrai, where irrigation developed in the low-lying areas first in the substitution of HYV boro for broadcast aman (a form of flood response).

(b) Cropping intensities were generally assumed to increase moving up the landscape, i.e. lowest cropping intensities are on F3 land. On F3 land in general the number of crops that can be grown apart from boro is limited, primarily to deepwater aman, some oilseeds and some pulses. In general the deepwater aman area was allocated, first to F3 land, then to F2 land, assuming that all non-irrigated land on those flood phases, plus 25% of the land growing boro, would grow deepwater aman. The latter assumption reflects the tendency for farmers to try to grow deepwater aman (especially transplanted) after growing boro, particularly in parts of the Lower Atrai basin where boro is harvested early.

(c) Most of the remaining crops were allocated to F0 + F1 land. Transplanted aman was always allocated to that land, while non-irrigated crops such as b. aus, jute and rabi crops were allocated, first to F0 + F1 land, then, if the area of the crop was greater than the available land (or if cropping intensities appeared to be too high), the remainder of the crop was allocated to F2 land (with some oilseeds and pulses on F3 land).

It was encouraging to note that this method of allocation gave consistent and plausible results, even though it involved matching two different data sources. This consistency lends credibility to the assumed with-project changes.

The same allocation rules were retained when moving from present condition to future-without and future-with conditions. The main change between present and future-without is an increase in the irrigation percentage, without any changes in flood phasing. Since it was assumed that, under present conditions, irrigation occurred initially on lower land, the assumed increases in irrigation under without-project conditions occur to a greater extent on higher land, generally replacing b. aus. Therefore the main change in cropping patterns assumed between present and future-without conditions was the substitution of b. aus (and sometimes rabi crops) by HYV boro.

The shift between future-without and future-with involves a change in flood phasing without any further change in irrigated area (at least in the NW Region, where protection of the boro from floods is generally not needed). The assumed shifts in flood phasing were determined on the basis of FAP 2 hydraulic and drainage analyses and judgement. The resulting changes in cropped areas were determined as follows:

(a) In general, it was assumed that cropping intensities would change little.

(b) In most project areas with a significant amount of F3 land, this land generally declines, although not always by much (under the Green River scenario a major decline in F3 land is by definition ruled out). Where a decline does occur, it implies a decline in the area of deepwater aman, and sometimes in oilseeds where they were grown after deepwater aman. In "flow" areas of the Lower Atrai a small increase in deepwater aman was assumed to take place, reflecting the partial protection provided by the project.

(c) Where F2 land is also assumed to decline, this also results in a decline in deepwater aman and sometimes in pulses and b. aus. Total jute areas were assumed generally to remain the same or decline slightly, but more of this jute would now be grown on F0 + F1 land.

(d) The main changes in flood phasing generally involve an increase in F0 land, and sometimes in F1 land. Although the overall area of HYV boro stays unchanged compared with without-project conditions, more of this boro is now grown on F0 + F1 land. In terms of actual changes in areas of individual crops, the main changes involve increases in HYV t. aman, shifts in either direction in the area of local t. aman, and sometimes further declines in the area of b. aus.

The above changes need some explanation. In general it is assumed that, under present conditions, HYV t. aman is more likely to be grown on higher land than is local t. aman. There is not a strict division, however: some HYV t. aman is grown on F1 land, and some local t. aman on F0 land. The present extent of HYV t. aman and local t. aman is however not just a function of water levels. There is a degree to which some farmers have not yet adopted HYV t. aman because of high input costs, taste preferences etc., although this number is certainly declining. There is also an indirect constraint imposed by irrigation. If irrigation is not available, farmers may grow rabi crops and b. aus, in which case it is difficult to follow this by HYV t. aman, whereas it can be followed by local t. aman which has a shorter growing period. When irrigated HYV boro is introduced, it is easy to follow this by HYV t. aman, at least on F0 land.

This discussion therefore implies that not all the shift from local t. aman to HYV t. aman can be attributed to FCD projects but, by holding irrigation constant between future-without and future-with, it is possible to isolate the shift that is a result of flood control. As a further consequence of that shift, farmers may abandon cultivation of b. aus + rabi crops, implying, if anything, a decline in cropping intensities.

The main shift that has been assumed to occur on F0 + F1 land is therefore, an increase in HYV t. aman. The extent of that shift has generally been taken to be some proportion (generally about 80%) of the increment in F0 land. This proportion is derived from the existing proportion of HYV t. aman to F0 land (generally 60-75%) and assuming some intensification. Where F1 land has declined, it is assumed

that local t. aman also declines, i.e. much of the increase in HYV t. aman area is a straight substitution of local t. aman. Where the F1 area stays constant or increases, it is assumed that local t. aman also stays constant or increases.

It is felt that the approach outlined above allows a generally realistic forecast to be made of shifts which are genuinely the result of flood control and not of other simultaneous changes such as irrigation development. If the resulting forecasts are more conservative than some predictions made in the past, it is felt that such an outcome is nonetheless realistic.

5.2.3 The Gaibandha Project Preparation Study

In this case an attempt was made to carry out a more sophisticated analysis of forecast cropping patterns using the model.

The output from the model was used to calculate, according to depth of water levels at different "decads", ten-day periods of the month, the area that can be cropped under the different broadcast and transplanted rice crop, jute, and "rabi". The model cannot differentiate between the rabi crops because to a large extent the one to grow is decided on economic and not agronomic grounds. Nor does it allow for farmer decisions like not planting b aus because of late or failed rains and instead to plant t aman earlier, to be followed by a rabi crop. Nor is it accurate enough to distinguish between conditions which favour HYV t aman against those suitable for local t aman. However, on the whole the model gives a useful guideline on what can be done. Since, by definition, it compares like with like, i.e. the same kind of errors would occur in the without-and with-project calculation, it is a useful initial planning guide.

The present cropping pattern is calculated according to the model which uses the 1:5 year water levels and the time these are reached. It is assumed that the present irrigated area equals the area of boro, and the overall cropping pattern is adjusted accordingly between the irrigated and non-irrigated derived patterns. Next, it is adjusted to include crops that the model does not calculate. Future cropping patterns are calculated the same way, but adjustments are made for the expected increase in the irrigated area and for the recognised fact that with increasing irrigation and better flooding conditions the area of the non-profitable miscellaneous crops decreases, depending only on soil conditions. This approach is suitable for project preparation, although in some cases it would help if more pertinent information could be gained about areas for which the BBS data have to be apportioned.

The methodology is described in more detail in Appendix 4.

ANNEX 1

THE GAIBANDHA PROJECT

1. Climate

The project area lies in the north-eastern part of the region, in Physiographic Unit no 2 (see Appendix 1). The eastern boundary is the Brahmaputra Right Embankment, the northern the Teesta right Embankment. It stretches south for about 50 km. Rainfall is between 1,750 and 2,000 mm. Winter temperatures are relatively low.

2. Soils

The soils derive from the Teesta, are of medium to medium-heavy texture. Unlike many of the soils derived from the Teesta alluvium, they dry out reasonably quickly after the rains have stopped. Therefore it is possible to prepare the land in time for the major rabi crop which is wheat.

3. Present Agricultural Development

3.1 The Cropping Pattern

The present cropping pattern as reported by BBS, is below:

Crop	%	Crop	%
HYV boro	29	HYV t aman	41
l t aman	43	b aman	tr
b aus	20	jute	19
wheat	9	oilseeds/pulses	5
potatoes	1	vegetables/spices	1
tobacco	1	others*	tr

Total cropping intensity: 170%

* sugarcane 244 ha; orchards 22 ha.

The table shows that, as in the rest of the region, rice is by far the most important crop: it occupies about 133% of the cropped area. Jute is important, its area is well above the regional average of 7%. The reason is its well established market and the number of buying centres operating in the project area. The wheat area is also above average for the region, due to the cool winters and the retentive nature of the soil which enables a reasonable crop to be grown on residual moisture. Conversely, the area of oilseeds and pulses is low: the predominant rabi crop, after boro rice, is clearly wheat. Oilseeds and pulses are, a rule, principally grown on lighter soils and in climates where wheat is not a reliable crop. The small area of tobacco, most of which is concentrated in the north-west, near Rangpur, is taken to the large tobacco market in Rangpur.

Present yields in the project area are estimated as follows. They are about the same as regional averages except that jute and wheat, which is mostly un-irrigated, yield better than elsewhere.

Crop	Yield (t/ha)	Crop	Yield (t/ha)
HYV boro	5.0	wheat*	2.0
HYV t aman	4.0	oilseeds	0.6
b. aman	1.7	jute	1.9
b aus	1.3		
l t aman	2.3	pulses	0.7

* not irrigated

3.2 The Crops

3.2.1 Rice

(a) HYV boro occupies virtually all the irrigated area. Potentially there is almost no restriction imposed on its growing because of early floods. On the entire GCA, 57,600 ha, water levels over the growing period would allow it to mature on all but 115 ha. This is based an analysis of 1 in 5-year water levels.

(b) The HYV t aman area could, because of the water levels and times of rise, be larger. It is not happening, for some or all of the following reasons:

- the local variety can be planted later and requires less purchased inputs;

- well over half the t aman at present follows b aus, which restrict the time between harvesting b aus and the optimum date when it is advisable to plant HYV t aman. Thus it would be possible to follow more of the b aus with HYV t aman if farmers were to give priority to land preparation for the rapid changeover between the crops instead of threshing and storing the b aus. However, given the high rainfall in the area they give priority to secure the crop already grown before embarking on the next one. Planting HYV t aman late could mean that it would flower at a time when pollen sterility, due to low temperatures, could be a problem.

- Taste preference for the local variety may also play a part, although when grown for sale there does not appear to be a price difference between the HYV and local that would cover the difference between expected yields and returns.

(c) B aus occupies some 20% of the area. This is less than the water levels would permit: jute occupies much of the land where b aus could be grown (Section 3.2.2 (a).

(d) The area of deep-water rice, - a generic term used to cover broadcast as well as transplanted floating rice: TDW and b aman -, is insignificant, indicating that water levels in the area not cropped in the monsoon are generally too deep for a crop to be grown.

3.2.2 Other Crops

(a) The area of jute is considerably higher than that demanded by the water levels and times [Section III.2.1(c)]. But, as noted elsewhere, jute can take the place of b aus but not the other way round. The project area is a traditional jute-growing area.

(b) Wheat is an important crop because of the favourable soil and climatic conditions. It is not irrigated and therefore it seems likely that with expanding irrigation the area will be reduced.

(c) Oilseeds and pulses are, in most areas, "last-resort" crops, planted either where the soils do not allow more profitable crops to be grown or as catch crops between the major enterprises. The soils are sufficiently retentive of moisture to consider other crops and evidently farmers are doing so.

(d) Other crops: sugarcane, vegetables, tobacco, orchards, occupy about 3% of the cultivable area. Therefore if market conditions were to permit it, it can be assumed that the area would be larger, at the expense of some of the other crops. This is obviously not the case and therefore, for planning purposes they need not be considered.

4. Expected Developments

4.1 Without a Project

Without a project the only likely change will be in the irrigated area and therefore the potential area for boro. This is expected to increase from the present 29% to 48%. Therefore the expected future-without-project cropping pattern would be as follows:

crop	%	crop	%
HYV boro	48	HYV t aman	47
l t aman	42	b aman	tr
b aus	9	jute	17
wheat	8	oilseeds/pulses	5
potatoes	1	vegetables/spices	1
tobacco	1	others*	tr

Total cropping intensity: 180%

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* sugarcane 200 ha; orchards 20 ha.

The rationale of the expected changes is the following:

(a) Boro will increase because it is the most profitable irrigated crop. This is most likely to happen at the expense of b aus.

(b) Because of the reduction in b aus, there will be no problem to secure the boro harvest before preparation for the HYV t aman has to start and consequently the area will increase. No significant difference in the l t aman area is expected: the b aus harvest over a smaller area will take less time and therefore following a larger proportion with either of the t amans is feasible.

(c) It is expected that the jute area will decrease slightly because of possible market conditions.

(d) The decrease of the wheat area will be due to its being replaced by boro.

(e) The area of the other crops will remain substantially the same.

(f) Because the work load by the farmers is spread more evenly, - the rush to harvest b aus and prepare land for t aman having lessened with the additional boro area, - it is expected that the overall cropping intensity will increase.

4.2 With Project

The likely with-project cropping pattern is expected to be as shown.

Crop	%	Crop	%
HYV boro	48	HYV t aman	54
l t aman	43	b aman	tr
b aus	9	jute	14
wheat	5	oilseeds/pulses	4
potatoes	1	vegetables/spices	1
tobacco	1	others*	tr

Total cropping intensity: 181%

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* sugarcane 200 ha; orchards 20 ha.

The reason for the expected changes compared to the without-project situation are the following.

(a) There can be no change in the area of boro: the project has no irrigation component.

(b) The additional security from flooding risks will induce farmers to make the effort to plant more HYV t aman than they would without a project. Some of this will replace l t aman, some will follow the expected smaller area of jute.

(c) The point mentioned above will also bring about a reduction of the wheat area: much of it usually follows jute but with the lessened workload in August more t aman can follow jute, implying less land available for wheat.

(d) Similarly, oilseeds and pulses will to some extent be replaced by more profitable crops.

(e) No significant change is expected in the area of the other crops.

Cropping pattern diagrams are shown in Figure 1. The diagrams show the percentage of each of the crops grown now, future-without and future-with project. "Rabi", for convenience of presentation, has been grouped together: the separate crops occupy such a small area that they could not be properly shown on a diagram of this scale. The exact place where the different rabi crops fit into the crop calendar is also slightly generalised, for the same reason. However, the diagrams show that they do in fact fit readily into the calendar.

Figure 1

CROPPING DIAGRAMS

The diagrams also serve to show labour and land preparation peaks by indicating the extent of changeover time between crops that follow each other. For instance it can be seen that to follow boro with HYV t aman gives ample time to prepare the land, whereas to follow b aus, and, worse still jute with t aman could be difficult with the available labour and land preparation resources: securing a crop already grown clashes with preparing for one yet to planted. Farmers are more likely to secure what they have instead of taking risks with it, by preparing for the next one instead.

5. Possible Constraints to Cropping Intensification

In the Regional Report the present situation regarding labour available at peak periods and facilities for land preparation have been discussed. It was concluded that, overall, especially if an intensification of agricultural production is likely to take place throughout the country, present labour supplies, much of it migrants from other regions, may be inadequate. The problem of land preparation resources, especially the number and quality of draft animals, was also examined.

The situation for the Gaibandha project area is as follows:

(a) At present the area has surplus labour: people go to the area mainly between Borga and Naogaon to seek employment. There is every reason to suppose that these same people would prefer to work nearer home. Consequently no shortage of manual labour is expected. However, it is necessary to emphasise that this judgement is qualitative, based on field visits and discussions but no numerical data have been collected.

(b) The situation regarding draft power has also been probed. No numerical data are available but fewer of the farmers interviewed in the course of the May 1991 survey and later have reported constraints than in other areas.

(c) The additional production is expected to be rice and not a perishable commodity requiring rapid marketing before it deteriorates. Therefore no constraints due to the extra production spoiling need be expected, nor are additional processing facilities needed to handle the produce.

(d) However, the previous statement needs to be qualified. In view of the high rainfall in the area, and because some of the additional production will be boro rice, harvested during usually heavy rains,- the provision of additional drying facilities, in the form of suitable drying floors for the general public for rent, may well be necessary. However,this need is not dependent on the project, which will not affect the area of boro. No drying problems are expected for the increased t aman production; the area of b aus, the drying of which presents an even more serious problem than that of boro, will actually decrease.

APPENDIX 1

PHYSIOGRAPHIC UNITS OF THE FLOODPLAINS

The physiographic units of the region are shown in Figure 2. Those in which there are proposed projects are described below.

Teesta Floodplain (Unit 2)

Unit 2 includes the present and historic courses of the Teesta: the floodplains of the Atrai, Little Jamuna, Karatoya, Dharla and Dhudkumar. It is over 1 m ha in extent and can be found in parts of Panchagarh, Nilphamari, Rangpur, Gaibandha, Bogra and Naogaon districts. It is about 150 km from north to south. Its northern point is under the climatic inflence of the Himalayas, resulting in what are the coolest January temperatures of the region, indeed the country. Wheat, which requires a relatively long period of night temperatures below about 15 C for optimum tillering and ear initiation, can be successfully grown everywhere in the Unit. For best results it should be planted by about the 15th November in Naogaon and Bogra districts but it can be delayed until the end of November further north. Transplanting HYV t aman must be completed by mid-August in the northern districts but can be delayed until later in the month in the south. Local varieties of t aman can be planted up to about three weeks later.

A relatively small sub-unit needs to be identified: the active floodplain between the Teesta river and the at present is only partly existing right embankment. As in all active floodplains the soils are more mixed and therefore much more attention needs to be given to detailed farm planning than in the rest of the unit. Most of the lowlands are in this sub-unit.

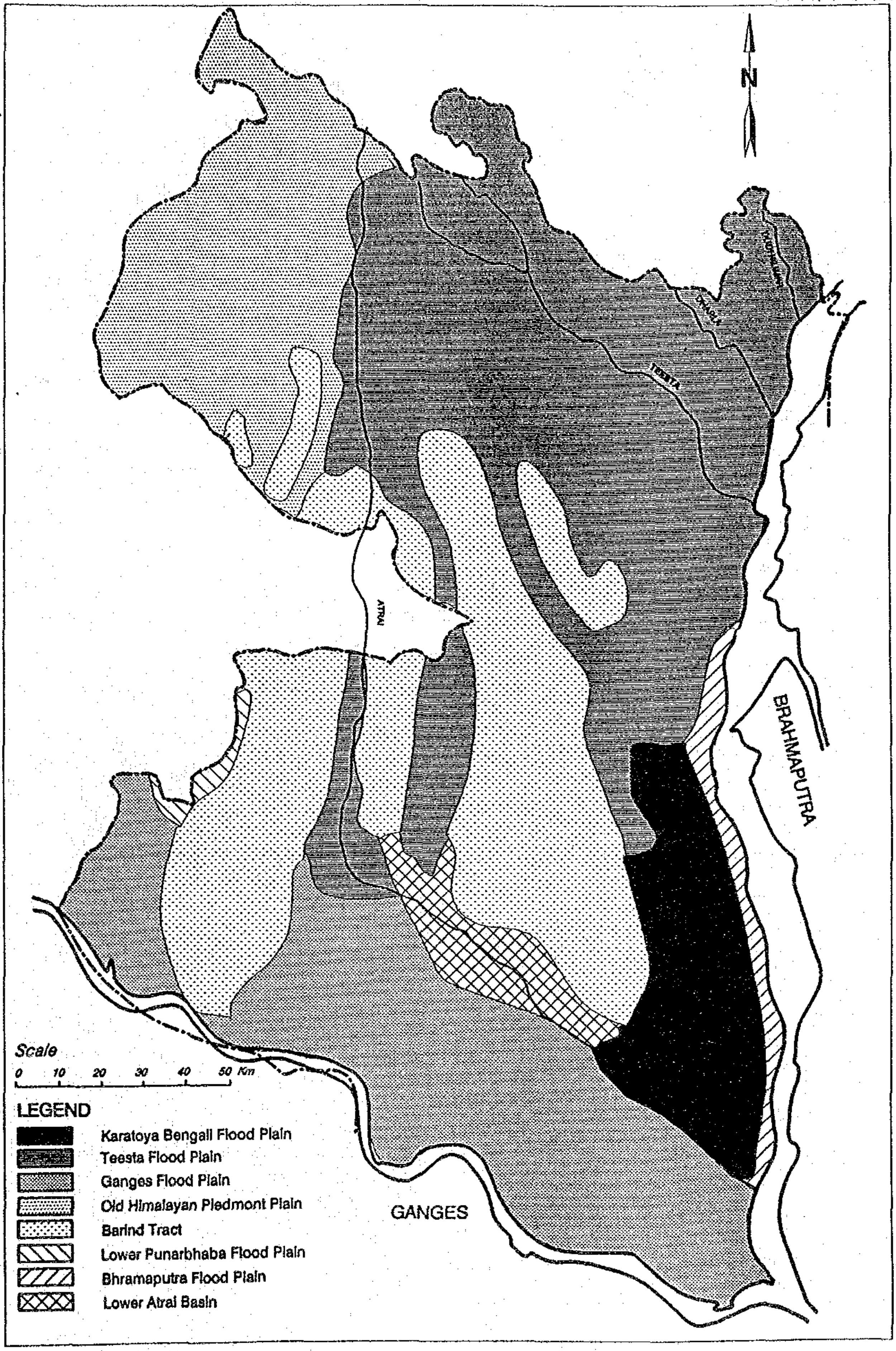
The soils are mostly loams with small areas of sands and clays. As one moves southward, they get heavier. Moisture is retained well into the rabi season, which means that land preparation may not be possible for a rabi crop and can only be done for boro in January or, where there is no irrigation only for b aus in February or later, in places making the growing of crops other than boro or aus rice difficult or impossible. This is largely due to the shallow ploguhpan. This, however, is not a problem if the crop is rice and therefore careful thought must be given to the advisability before incurring the labour and expense to break and reestablish the ploughpan every year.

Karatoya Bangali Floodplain (Unit 3)

Unit 3 occupies a strip along the Brahmaputra-Jamuna river, in Gaibandha, Bogra and Sirajganj districts. It covers about 260,000 ha, two thirds of which is highland or medium highland and the rest lowland. The Unit is similar the Teesta Floodplain except that before the building of the BRE it was subject to regular flooding and therefore received silt deposits from the Brahmaputra.

Climatically it is less extreme than Unit 2: the cooler weather starts later and high kharif temperatures are lower and of shorter duration than in other parts of the region. Therefore, for best results, wheat should be planted by about mid-November. The transplanting of HYV t aman should be completed by about the 20th August, that of the local varieties a month later.

Figure 2
PHYSIOGRAPHIC UNITS



About two thirds of the area has medium-textured loam soils; a quarter is clay. The relatively shallow ploughpan in most areas could be a problem if extensive rabi cropping were to be practised. However, on the lighter soils, and possibly everywhere in the Unit, it may be wiser to plan for short-duration rabi crops like the Brassicas, pulses and sesamum, to preceed t. aman. These crops are more tolerant to a shallow seedbed and would give acceptable yields with less effort and inputs than wheat.

Lower Atrai Basin (Unit 4)

Unit 4 extends to about 85,000 ha. It occupies both banks of the Atrai river, on the borders of Naogaon and Rajshahi districts. Climatically it is similar to the Karatoya-Bangali Floodplain. Only about 10% is highland or medium highland. The soils are mostly acidic basin clays. They crack deeply when dry and become sticky and plastic when wet. This is no problem when preparing land for transplanted rice, but the growing of rabi crops is more restricted and requires considerable skill and care.

Lower Punarbhaba Floodplain (Unit 5)

Unit 5 is a small (13,000 ha) narrow strip of land at the extreme west of Naogaon district. It is a low-lying flood-prone area, differing from the ones nearby in that it has been derived from non-calcareous Teesta and Brahmaputra alluvium and not from the calcareous Gangetic deposits. Most of the soils are cracking acid clays. Some 70% is "low" or "very low" land.

Although the cool period is quite long, the nature of the soil may preclude the growing of unirrigated wheat and other rabi crops because of difficulties with timely land preparation. The likely major crop would be late boro/early transplanted aus where there is irrigation; broadcast local and possibly HYV transplanted aus without irrigation if safe from July floods.

Active Brahmaputra Floodplain (Unit 6)

Unit 6 extends to about 150,000 ha in the North West region; the rest is in the north-east. It lies between the present course of the Brahmaputra and its right embankment in Kurigram, Gaibandha and Bogra districts. This north-south range of over 150 km predictates a significant climatic range: HYV t aman has to planted by about mid-August in the north but not till later in the south. Winter temperatures are marginal for wheat, nor are the soils suitable. Hence the prevailing land use in the rabi is mustard and pulses. A considerable area of sugarcane is grown for gur-making and for mills. Some 60% of the area is medium highland or medium lowland.

An outstanding feature is the extent of "char" lands: lands newly deposited. They are sandy and the ownership is in doubt. Because of their shifting nature, permanent development is hazardous.

The Gangetic Floodplains (Unit 7)

Three sub-units can be identified: the Active, the High and the Low Gangetic Floodplain. Total area is about 800,000 ha. It forms part of Nawabganj, Rajshahi, Natore and Pabna districts. Less than a quarter are lowlands. Soils are mostly of medium or medium-heavy texture and, as typical of Gangetic alluviums, calcareous, making them eminently suitable for sugarcane. Sugarcane yields have increased spectacularly during the last several years. Further considerable improvements could be had if irrigation at times of acute water stress proved practically and economically feasible.

Climatically, conditions become more moderate from west to east: there is more latitude in aman rice planting, and less tolerance to late planting of wheat. In the western parts of the unit rainfall is the lowest in the country. Often it is not possible to follow b aus with t aman through lack of sufficient and timely rains.

The range of rabi crops is wider in this unit than anywhere in the region. This is not only a reflection or farming standards, but also indicates the superior quality of Gangetic alluviums compared to those deposited by the northern rivers.

APPENDIX 2

CROPS OF THE NORTHWEST REGION

1 Rice

1.1 Introduction

As in the rest of Bangladesh, in the North-West there are three rice seasons: the winter or rabi; the early monsoon, approximately equivalent of the northern hemishpere's spring; and the main monsoon, spanning the northern hemishpere's summer and autumn. The three rice crops are the boro, aus and aman.

The "Green Revolution", spearheaded in Bangladesh by the International Rice Research Institute (IRRI), has in the late 1960's and early 1970's introduced high-yielding strains. They helped to establish the Bangladesh Rice Research Institute (BRRI) where new varieties are being bred and introduced ones reselected and acclimatised. All have been readily accepted by the farmers.

1.2 Boro or Winter Rice

The earliest success has been with boro varieties. These can also be grown in the early monsoon as aus crops (Section 1.3). The region's cool winters predicate relatively late plantings. Cold-resistant varieties that could be planted earlier and would mature sooner have to date not been developed. Therefore most of the transplanting of HYVs is around the middle of February, for harvest in late May or realy June. Local varieties, which yield about half that of the HYVs, are more cold resistant, are transplanted two to three weeks earlier, stand deeper water because of their taller stature and mature from about early May onward. Transplanting HYVs earlier does not mean an earlier harvest: the usually cool weather until mid-February prevents the crop from developing and only adds to production costs: it requires irrigation and aftercare for longer than the more timely plantings.

An interesting feature of the boro varieties is that if flooding in the monsoon is not deep or delayed, they ratoon readily. The ratoon will not produce grain but its fodder value is important. For instance in 1991, which was a "normal" year for flooding, farmers were forced to feed water hyacynth to cattle. In 1992 when the floods were low the regrowth of the boro provided ample fodder and no water hyacynth had to be fed (Appendix 3).

Yields of HYV boro are 5-5.5 t/ha; of local boro, 2.5-3 t/ha.

1.3 The Aus or Spring Rice

Most HYV boro varieties can be planted as late as the second half of May if there is no risk of flooding: they can be grown in the aus, or, as often referred to, "braus" season, implying that they can be planted at any time between February and late May, ripening between late May and late August. The important caveat is that there has to be flood protection for plantings after late March. Unlike in other regions HYV aus is almost never broadcast in the North-West. However even if broadcast the yield is a marked improvement over the traditional varieties.

The local aus is usually broadcast. It is a short-term, low-yielding, "hungry gap" crop which provides food before the main-crop, aman, harvest. It is planted in April, to escape August flooding, and therefore often suffers from drought; more in the North-West where the rains start later than in other

regions. In 1992, a specially dry year, many farmers had to replant more than once. It ripens in late July or early August, at a time when the risk from floods is greatest, and is often destroyed or severely damaged. *It is the most risky of the rice crops.*

HYV aus, although the same varieties as HYV boro, yield less than boro, because there is less sunshine at maturing time. The yields reported are about 4-4.5 t/ha. Local aus yields are 1.6-1.8 t/ha.

An interesting recent development in areas with access to irrigation is to use the local aus as a third crop. If so used, it is transplanted after the boro harvest in early June, and matures in August. It can be followed by transplanted HYV aman.

Another system to grow three crops is to follow HYV boro with HYV t aus. It matures in late August and can therefore only be followed by the photosensitive local transplanted aman (see below) in September. Thus, three rice crops are possible. It should however be noted that both systems require irrigation facilities, flood-free conditions and, above all, reliably available means to prepare the land without delay between crops.

1.4 Aman or Main-Season Rice

There are two kinds: of fixed height, and one that can expand with rising water, the floating rice. Traditionally, the former are transplanted and the latter broadcast. A recent development, initiated by farmers, is to tranplant the floating rice.

1.4.1 Fixed-height Aman

The fixed-height, or transplanted, aman (t aman) is the main rice crop of the country, grown over the largest area. All the traditional fixed height aman varieties are photosensitive, but the earlier HYVs are not. This point is particularly important in the North-West Region where HYV t amans may suffer from pollen sterility if planted late, with consequent severe reduction of yield if the cool weather starts early. However, some recent releases from BRRI, which are slowly gaining popularity have overcome this problem. Because of their lack of photosensitivity, the earlier HYV t amans must be planted not later than the second half of August. If planted later, they are likely to suffer from pollen sterility. In contrast, the local varieties can be planted as early as mid-July or as late as the end of September. While late planting affects yield by shortening the growing season, it secures a crop which yields better than the local varieties.

1.4.2 Deepwater Rice

Deepwater rice is broadcast at the same time as aus, in April. It is strongly photosensitive and does not mature until late November or early December. It is often planted mixed with the traditional aus, which is selectively harvested in August, leaving the deepwater aman to face the by then usually rising waters. If not too sudden, it can withstand as much as 10 cm in a day.

Deepwater rice is the most adaptable of the three species. Be-cause it is photosensitive, it can be broadcast after boro. This is not usual because June plantings have not enough time to develop to the stage where they can withstand the rise of water in August. 1992 was an exceptional year, -according to farmers a one-in-ten year, - when those who took the risk of following boro with broadcast deepwater rice have been successful.

Another innovation is to transplant deepwater rice after boro. This practice is more likely to be successful than late broadcasting: the seedlings are usually about 1 m tall, establish rapidly and therefore have a better chance to withstand August floods than if broadcast in June. The practice is gaining popularity but is constrained by labour shortage at the time of the boro harvest which necessarily takes priority over preparing for a more risky crop. While this fact is not yet fully verified, many sources report better yields from transplanted than from broadcast deepwater rice.

Typical yields of the deep-water rices, often referred to a b aman, are just under 2t/ha.

2 Jute

Jute, the "golden fibre" of Bangladesh, is on the floodplains of the region the second most important crop, occupying about 7% of the cropped area. Two species are grown. Chorchorus olitorius, tossa, matures later than C. capsularis, desi phat. There is small area of kenaf, mesta, grown on the poorer soils in the more flood-prone areas. In recent years the C. olitorius is gaining in area at the expense of C. capsularis.

Jute has been regarded as a dying crop for many years, the expectation being that artificial fibres, especially proypropylene, will replace it. It has done so largely for sacks, even within Bangladesh, but the market is holding up for other uses and the area does not appear to be diminishing significantly. One of the reasons is that it is used within the household for ropes, and that the "sticks", the stems after the fibres have been stripped, is a valuable fuel, often traded.

Jute is planted in March-April and harvested in August; the harvest of C. olitorius often reaches into early September. Water levels permitting, it can be followed by t aman, but because of the lateness of the harvest it is usually l.t aman. The crop will stand a greater depth of water than b aus after about mid-May: up to about 1.50 m. Thus, while jute can be grown with the water regime suitable for b aus, the reverse is not the case.

Yields have been fairly static over the years: in the region of of 1.6-1.8 t/ha. Improvement is difficult. The crops that showed dramatic yields increases over the years, wheat, rice, cotton and maize, have been bred for increased branching, tillering, producing longer ears, more branching panicles or more than one cob. Jute on the other hand must not tiller or branch, which would affect fibre quality. The only way to increase yield is by a higher plant population and greater height; both have their limitations.

3 Wheat and Barley

Wheat and barley are traditional crops. Many species of barley are grown: ears with six, four and two rows of grain. However, since the early 1970's barley has lost much of its importance. It is only grown under poor soil conditions. In contrast, the wheat area has increased considerably: at present it just about equals that of jute.

The North-West is climatically best suited in the whole coutry for wheat, especially the old Dinajpur district, and to a lesser extent the area at the latitude of Rangpur, under the climatic influence of the Himalayas. In these areas, given proper care, - and irrigation, - yields of 3.0-3.5 t/ha are by no means rare. Further south yields decline dramatically and are nearer about 1.3-1.7 t/ha. Many growers explained that in cool winters, like in 1991-92, yields are far better than under the more usual temperatures. The main management problem is the logistics of irrigation:

(a) the command area of a well is much larger than if irrigating boro rice;

(b) the intermittent irrigation wheat requires causes the channels to dry out between irrigations, resulting in heavy water losses, and consequently increased pumping costs, to re-wet them; and

(c) the irrigation network gets destroyed during the monsoon, when the rice following the wheat does not require irrigation and the inevitable flooding destroys the channels, requiring annual rebuilding.

Notwithstanding the foregoing, wheat irrigation has been observed around Rangpur, but it was almost invariably done by indigenous devices, usually shadufs. Nonetheless, excepting the Thakurgaon area, - one not of primary interest for FAP2, - wheat is a minor crop, confined to light soils which are the last to be brought under irrigation if at all, and to fields that for some reason have not been levelled sufficiently for rice. Yield under such conditions is not expected to be more than about 1.2-1.5 t/ha on the part of the landscape likely to be devoted to it.

One of the reasons, apart from the well recorded taste preference, - which however, is not as marked as it was several years ago, - is that planting time is critical: yield losses, especially in the average, usually mild winter, are severe when planting is delayed much beyond about the 20th November. Owing to the usual cropping sequences, which often predicate wheat to be planted after t aman, this timetable is difficult to follow. Farmers are aware of this and are reluctant to plant wheat late.

4 Minor Cereals

4.1 Millets

Two kinds of millets are grown as a late rabi/early spring crop: Setaria italica kaun and Panicum miliaceum chena. They are grown in areas not vacant soon enough to plant pulses or oilseeds. They mature in about 85-90 days and can be followed by b aus or b aman. They are typical "hungry gap" crops. Occasionally, especially on the higher patches, they are used as alternative to b aus. Yields are low but at least the farmer can be certain of some production. The straw is relatively good fodder. Yields rarely reach 1 t/ha.

4.2 Buckwheat

Although not a cereal, buckwheat, denshi, comes into the same category. It is more common in the more northern areas, since it thrives better under relatively cooler conditions. One advantage over the millets is its higher protein and mineral content.

5 Pulses and Oil Seeds

5.1 Pulses

A large number of different pulses are grown, mostly in the rabi but some, notably mungbeans, also in the late monsoon. Pigeon peas, the least widespread of the pulses, is a perennial or at least a 12 month crop. It is grown for its seeds, pods and the fuel value of its stems. It is increasingly seen around the homesteads.

The common rabi pulses are chickpeas, lentils and vetches. This latter is also a fodder crop, in that it produces relatively large amounts of stover. It normally follows b aman. On sandy soils, on charlands or where a market has been established, groundnuts are occasionally grown, mainly as a luxury crop, to be eaten without further processing.

5.2 Oilseeds

The oil crops are the Brassicas, Sesamum and safflower tishi. In the North-West the first two are the more popular.

There are two kinds of Brassicas: rape tori and mustard rai. The former is planted as soon as the land is accessible after the beginning of November and can be followed by late boro rice. Mustard is planted later, yields slightly better but vacates the land too late for winter rice. Sesamum is planted even later, in February. Yields of all three are low and no significant improvement is envisaged by the research institutes in the near future. They all yield around 1 t/ha.

Increased irrigation, flood control and drainage create conditions under which rice can be grown. As noted, all the rice crops yield higher than oilseeds and pulses and are more profitable even when the higher price for the alternatives is taken into account. Therefore farmers tend to switch to rice wherever they can and buy their household requirements of pulses, and even more of vegetable oils, on the proceeds of the rice they sell. Desirable as it would be to grow more pulses from a family nutrition point, it just has to be accepted that for economic reasons it is unlikely to happen. The FAP 12 studies as well as the FAP 2 investigations strongly support this contention.

6 Sugarcane

Sugarcane is extensively grown. There are several commercial sugarmills. Other uses are for jaggery gur making and for chewing, perhaps the biggest and most continuous year-round market. There is a research station in Ishurdi which has initiated some remarkable advances over the last 20 years or so. Yields have increased from 25-30 t/ha to about 45-50 t/ha, most probably due to the innovation of distributing pregerminated planting material in polythene bags and thereby greatly assisting good and early establishment, before the soils dry out in the rabi. Under supplementary irrigation during the dry season there are records of 65-70 t/ha and even more.

Nevertheless the area is not increasing. It is usually grown where other crops, notably boro rice, is not economical because of the permeable soil or because the watertable is so deep as to make boro irrigation difficult. This is the case on much of the Gangetic plains where the concentration of sugacane is the highest, and yields are the best. Since it will stand flooding up to 1.50m it is often confined to such conditions. Irrigation has the same logistic and management problems as described for wheat. A major issue militating against it becoming a major industrial crop is the low recovery rate of the factories: they report only about 8.5%.

7 Other Crops

VII.1 A large number of other crops are also grown, in localities that tend to be defined as much by marketing facilities as by soil conditions. These are, to mention a few:

(a) tobacco, especially in the Rangpur area but also elsewhere;

(b) the many kinds of rabi and monsoon vegetables and spices, including betel leaves, usually near the larger towns like Rajshahi or where transport to major markets is readily available: near Pabna for the Dhaka and Chittagong markets;

(c) mango and banana orchards, the former mostly on the Gangetic plains;

(d) potatoes, mainly in areas where there are cold storage facilities;

(e) sunnhemp used to be a popular crop for the making of fishnets but the use of nylon nets has reduced demand;

An interesting practice with potatoes is partially to harvest the crop by removing only the larger tubers, thereby encouraging more to develop and the smaller ones to grow.

All these crops receive the greatest possible care and attention: the husbandry practices are remarkably painstaking, indicating the high returns that the growers expect.

Yet another crop seen is not a cultivated crop at all: thatching grass, chan. Areas are set aside for it to grow unimpeded, and is usually sold as a standing crop, for around Tk 11,000/ha. It is also grown on field boundaries, for use by the grower. An interesting use is on charlands, where if planted at the right place it filters out the silt from the river water and can be used to build up land.

8 Sesbania

Finally, a crop that appears to be gaining popularity has to be mentioned. It is grown for fuel. This is Sesbania sesban, doncha. It is a perennial shrub but is often grown as an annual. Both the leaves and the stems are dried for fuel, usually by the grower but it is increasingly traded. Not only is it grown on field boundaries but often as an alternative to b aus or jute, near homesteads. When grown for sale, it is worth more than Tk 7,000/ha, the buyer doing the harvesting and drying.