Wet-rice Cultivation in Lowland Bangladesh

Tetsuo Satoh*

In this article cropping systems of wet-rice cultivation in a backswamp are described from both physical and socio-economic viewpoints in order to discuss the probability of the adoption of modern rice varieties (MVs) in lowland Bangladesh. The discussion is based on a case study in a backswamp located in the southeastern part of the country.

It is concluded that recent dry season MV cultivation is competitive with traditional cropping systems in a large part of the lowland. There are no physical constraints on the MV growing where land is dried up by the end of February and, at the same time, water is available during the dry season. In economic terms, the MVs will be able to replace local mixed-sown tall varieties only when the material cost of irrigation is reduced to a reasonable level.

In contrast, in the lower part of the area, dry season MV cultivation is risky or even impossible because of the long duration of submergence. The rice production capability of such lower land is not necessarily inferior in economic terms insofar as it is under pure floating rice cultivation, therefore traditional cropping systems will remain for a while. This type of floating rice cultivation is commonly observed in the backswamps on the lower Ganges delta by LANDSAT images.

I. Introduction

The characteristics of Asian wet-rice cultivation are summarized by Grigg (1974) as follows:

a. small family farm
b. subsistence farming
c. high inputs of labor
d. intensive land-use
e. unimportance of livestock
f. specialized in rice

These characteristics are more or less related to one another, and supported by the following techniques of growing.

a. irrigation (including leveling and bunding of plots)
b. terracing (on hillsides)
c. multiple cropping
d. transplanting
e. rare rotation

It can be pointed out that the principle of farm management lies in the intensive land-use. Although this is a model of traditional Asian wet-rice cultivation before the 1970s, the basic structure of the farming systems has not been changed but rather have been confirmed by modernization.

The green revolution has passed through three steps of innovation originating in the improvement of varieties; high fertilizer responsiveness and photo-insensitivity (IR 8), pest and disease resistance (IR 20), and short growth duration (IR 36) (Herdt and Capule, 1983). These modern varieties (MVs) have spread over traditional rice cultivating areas with a set of modern techniques such as a proper planting rate, irrigation and drainage, fertilizer application, and the use of pesticides and herbicides. Even the main cropping season was shifted from the wet season to the dry season in some areas where water is available all year round, thus gaining a more stable climatic condition. In short, MVs enhance the aspect of intensive land-use since a highly intensive cultivation increases paddy yield and shorter growth duration enables expansion of multiple cropping (Barker and Herdt, 1985).

As is often mentioned, such well-equipped land with irrigation and drainage facilities is very limited in South and Southeast Asia, thus contributing to the stagnation of areal expansion of MVs' planting. However, at present, research priority is given to the development of varieties and techniques more adaptable to rainfed wet-rice cultivation (Barker and Herdt, 1979). A vigorous challenge is being continued in the lowlands of
flood plains where standing water depth in the wet season exceeds more than 50 cm, or so-called "deepwater areas" (Kush 1984). This forth or fifth phase of innovation in deepwater areas cannot promise its success unless it is consistent with the local deepwater rice farming system. It should be recalled that the early green revolution was accepted by farmers because it had no contradiction to the principle of local farming system.

Some characteristics of wet-rice cultivation above mentioned seem no longer effective in deepwater areas. Takaya (1975) describes physical environments and rice cropping patterns on South and Southeast Asian deltas. In the deepwater areas, rice is usually broadcast and grows under droughty conditions before flooding during the late vegetative stage and reproductive stage. According to a case study in a deepwater area of Chao Phraya Delta (Tanabe, 1980), the traditional cultivation is still practiced even after modern techniques were introduced with the construction of irrigation facilities, for "the field is too deep to adopt early season cultivation" with MVs. Yet the report also mentions that the farmers do not have any objection against intensive land-use.

Compared with a variety of reports we have had on the farming systems in Southeast Asian deltaic regions, much less information is available on the Ganges delta. This adds urgency to the collection of more detailed data on the physical environment as well as on the present local farming systems in lowland Bangladesh. Komoguchi (1982) concludes that the rice cultivation in Bangladesh is designed with close relation with the seasonal fluctuation of water level. The lowest land, such as riverbeds or canal channels, is planted with traditional dry season rice, while the second lowest land is utilized for deepwater rice which is broadcast in April and harvested in December. The model also refers to the possibility of substitution of dry season MV rice for present deepwater rice on the second lowest land.

Actually, since MVs were first introduced in the early 1960s, they have been substituted mainly for traditional dry season rice. The spread of MVs seems to be waning in recent years, suggesting that currently available MVs cannot cover the deepwater areas. The percentage of land planted with MVs reached more than 60% of the dry season rice area in 1980, but only 15% of the wet season rice area which at that time accounted for 90% of the total rice area.

If the limitation of modernization mentioned above certainly applies in the case of Bangladesh, the problem is far from negligible. According to the 1977 agricultural census, 61% of farmland is classified as "medium" or "low level" where "water level in Bhadra month (the late August and early September) is over knee" (BBS, 1985). Figure 1 shows the percentage of deepwater rice fields in each of the regions (Huke, 1982). This is not completely accurate because statistics are not available for deepwater varieties. But this map seems reliable enough to conclude that the deepwater rice area lies in the central part of this country where flood plains of the Ganges and its tributaries are located.

LANDSAT images show that continuous backswamp depressions located on the south side of the Ganges River are fully covered with the rice maturing in November (Fig. 2). The sign of vegetation in the backswamps is not observed in the images taken from January to May (Fig. 3). These backswamps seem to be laid fallow during the dry season.
season, and therefore the area can serve as a testing case of the magnitude of MVs in the lowland. Accordingly, a village, Mollahat, in the backswamp area was selected for a case study.

This article presents some features of agricultural land utilization in lowland Bangladesh to which Komoguchi's model refers relatively less. Through the evaluation of local rice cropping patterns, the probability of technological change in lowland will be discussed from both the technological and the economic viewpoint. The focal points are to what extent the farming system in lowland is based on the deepwater rice cultivation and whether or not modern rice cultivation techniques will be adopted in that area.

2. Physical conditions of the area under study

Mollahat, the upazila studied here, belongs to Bagerhat District and is adjacent to Khulna, Narail and Gopalganj Districts that lie just beyond the rivers. The average of monthly mean temperature and monthly rainfall in Khulna from 1972 to 1981 is shown in Figure 4. Due to the proximity to the mouth of the river (about 100 km), the ebb and flow of water in the rivers and canals fluctuates in the dry season. However, there is no record of crop
damage caused by brackish water so far. A
general map of Mollahat is given in Figure 5. It is
easy to identify well drained areas by the distribu-
tion of housing sites and roads which are often
accompanied by canals.

While the riverfront areas on the natural levees
are relatively high and well-drained, the inner
areas are backswamps. This backswamp is
divided into several *bils* according to the old natu-
ral levees, and the more distant a *bil* is from the
river, the larger and deeper it is. In other words, a
*bil* is surrounded by relatively high land, with its
lowest part in the back of the center, like a skewed
saucer.

A cross section of the backswamp is illustrated
in Figure 6. Moving away from the emerging sand
bar where no one has yet settled, land level
declines gradually. There is a new village on the
levee where land is rather rugged and is thus uti-
lized in various ways like a mosaic pattern accord-
ing to its land relief (#1 in Fig. 6). Wheat and
vegetables as well as rice are grown with supple-
mental irrigation from the river supplied by sta-
tionary low-lift pumps. In the dry season, some of
the upland fields is covered with residua of water
hyacinths for mulching. Even the bottoms of
grooves are utilized as rice nursery beds, and later
the seedlings are mainly transplanted on the river
bed. A small *bil*-like depression is surrounded by a
man-made dike for roads (#2), where tall varieties
of rice are grown in the wet season as in the *bils*.

There is a small *bil* utilized as paddy fields
between old natural levees (#3). On the levees,
main roads and clusters of houses are located
amid forests with fruit trees and bamboos (#4).
Among the forests are also gardens of betel leaves,
betelnut palms and coconut trees. Those cash crops are shipped mainly to Dhaka by boat, taking a whole day.

The peripheral area of settlement units is developed for fields of sugarcane and reed for thatching, and for gardens of date palms and palmyra palms (#5). These upland fields are gradually changing into bunded paddy fields, which keep the water at shallow levels in the wet season and are transplanted to rice (#6). The rice is often MV (IR 20 for the wet season and IR 8 for the dry season), and double cropping is feasible especially in the area where irrigation is available.

Where bunded paddy fields terminate, submerged unbunded fields appear. These fields are cultivated for broadcast rice, jute or sometimes both mixed with each other (#7), but only deepwater rice can be grown where water depth in August exceeds one meter (#8). Sometimes a bil is traversed by several isolated high lands making a line from the edge of the bil, or by artificial dikes with both sides dug in. Some settlements are extending toward the bil along the dikes. Such depressions in a bil as creeks or waterways for boats are often utilized for traditional dry season cropping with supplementary irrigation from canals and fish ponds. The lowest part of the bil where water depth in August reaches nearly 2 m is utilized only for floating rice (#9).

Land-use patterns mentioned above are summarized in Table 1. A bil is simple or rather uniform in respect to land-use but major in area, and therefore it seems adequate to the research purpose here.

### Table 1 Relation between Landform and Land-Use

<table>
<thead>
<tr>
<th>Landform Unit</th>
<th>Land-Use</th>
<th>Crops</th>
<th>Regime of Rice Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>River bed</td>
<td>Uniform</td>
<td>Rice</td>
<td>Unbunded, dry season only</td>
</tr>
<tr>
<td>Natural levee</td>
<td>Complex</td>
<td>Rice, wheat, pulses, etc.</td>
<td>Diversified</td>
</tr>
<tr>
<td>Old levee</td>
<td>Complex</td>
<td>Fruit-tree, betel, etc.</td>
<td>—</td>
</tr>
<tr>
<td>Edge of levee</td>
<td>Simple</td>
<td>Rice, date palm</td>
<td>Bunded, partly irrigated</td>
</tr>
<tr>
<td>Peripheral bil</td>
<td>Simple</td>
<td>Rice, jute palm, sesame</td>
<td>Unbunded, intermediate</td>
</tr>
<tr>
<td>Central bil</td>
<td>Uniform</td>
<td>Rice</td>
<td>Unbunded, deepwater</td>
</tr>
</tbody>
</table>

3. Technological analysis of rice cropping patterns

As is well-known, traditional rice cultivations in Bangladesh are classified into three groups according to harvesting time: *boro*, *aus*, and *aman*. It is said that this traditional concept of rice varieties reflects the quality of grains determined by their respective ripening season. In this area, *boro* is harvested from April to May, while *aus* is harvested from August to September and *aman* from November to December.

This definition, however, is not always applicable because the harvesting time of a late maturing
variety of one group is immediately followed or even overlapped by that of an early maturing variety of another group. For example, early maturing aman varieties harvested in October form a sub-group named “digha” in this area. Furthermore, recent MVs are categorized as a new group called “irri” because of their independence of growing season. Such relay harvesting throughout the year is the first noticeable trait of the cropping pattern in the bil.

The second trait is mixed cropping of different rice groups. Rice cultivation in the bil is mainly based on deepwater rice. These are broadcast aman (bona aman), most of which are mixed with aus or jute. Similarly, in the case of local boro cultivation, a variety of aman called “rayada” is sometimes mixed together and sown in the same nursery bed. When aus or boro has fully ripened, all the stalks in the field including aman at the vegetative stage are reaped and cut, and after that, only aman ratoons among the stubbles. This practice of mixed cropping is often justified by the avoidance of risk and by the demand for an increase in yield.

A model of the cropping pattern is given in Figure 7. The two traits mentioned above are more salient when compared with a case in the peripheral area where double cropping is commonly observed with aus followed by transplanted aman (ropa aman). There are three distinctive cropping patterns in the bil: pure aman (khali aman), mixed aman with aus (aus-aman) or cash crops, and boro basis which includes boro as single cropping (khali boro), boro followed by aus (boro-aus), and boro mixed with rayada (boro-rayada). Rice cultivation is designed with close attention to the seasonal fluctuation of the water level. In that model, three ordinal types of land levels, the higher, medium and lower, are tentatively provided. Roughly speaking, water depth in August is...
50-100 cm on the higher land, 100-150 cm on the medium land and more than 150 cm on the lower land. As a matter of fact, the paddy field in the *bil* is neither bunded nor terraced so there is no clear gap between different land levels.

Regardless of those land levels, a farming year usually ends with the harvesting of *aman* with strong photosensitivity in early December. In some higher land areas, prior to the harvesting, pulses or oil seeds are sown among the stands of rice to grow in a month. Where fields are still waterlogged in this season, only the upper part of rice is reaped, and the stems are left in the water. After the water runs off, the straws of rice in the stubble fields are burnt or gathered for the fodder of livestocks. Some fields are plowed before the soil hardens. In summary, the higher the land is, the more often the fields are plowed: three to four times in the higher land and once or twice in the lower land during the dry season.

On the other hand, *boro* cultivation begins where water remains standing. Nursery beds are prepared on the soil still saturated with water, and main fields are demarcated in the shallow water by temporary earthen bunds to preserve the water. Where *aman* cropping precedes *boro*, residua of rice stalks are heaped into rows for bunds. Because this is rather intensive work practiced in the water, an *aman* field is rarely planted with *boro*. As water is gradually reduced, the *boro* fields advance toward the central part of the *bil*.

The period between December and February is the coldest season and the daily minimum temperature often falls below 15°C in this area. The temperature in the *bil* at night is warmer by two to three degrees due to the existence of its water. This microclimatic condition promotes the germination and rooting of *boro* seedlings which are, nonetheless, superior to *aus* and *aman* in low temperature resistance. Between March and April, the hot, dry and sunny climatic conditions are suitable for the maturation of *boro* rice.

It is at the end of March when all the fields in the *bil* are dried and plowed. In the lower land, *boro* mixed with *rayada* is transplanted, while the earlier transplanted pure *boro* has already ripened in the higher land. Fields are plowed and harrowed twice to three times before rice seeds are broadcast at the beginning of April. Land preparation is finished beginning with the lower level, and within a month, the higher fields are also ready for seeding. At about the same time, the later transplanted *boro* in the lower land is harvested, and the *bil* begins submerging. The rise of water is sometimes too rapid for *rayada* to catch up with it since its leaves are cut with *boro*, and this makes the yield relatively low.

When *aus* mixed with *aman* is harvested from July to August, *aman* faces the danger of failure of continued growth due to the rise of the water. Therefore pure *aman* cultivation is the major pattern in the lower land. In contrast, in some of the higher land, soil moisture is occasionally insufficient for heading of *aus* in this season. In such fields, *aman* is sown not with *aus* but with jute or sesame and is harvested in July. Harvesting of higher land *aus* in September is immediately followed by the early maturing *aman* group, or *digha*, which is broadcast in the medium land as pure *aman*. Besides *digha*, a variety of *aman* excellent both in quality and yield is also grown as pure *aman* in the medium land. As the days become shorter in October, heads of *aman* rice appear and ripen in a month or so.

According to the data collected in Mollarkul, a *mouza* on a medium size *bil*, 52% of the total operating fields was under *aus-aman* cropping in 1984/85 while 20% was under pure *aman* and 10% under jute. Combination of sesame and *aman* occupied 8% and that of jute and *aman* 5%. Only 4% was planted to *boro* and *boro-rayada* (Table 2).

Average yield per acre was calculated only for the operators’ own plots from 0.25 to 0.75 acre because the records of yield seem inaccurate regarding the plots that is leased or too small or large in size. In *aus-aman* cropping, *aus* yielded 11 mds/acre (1,012 kg/ha) in paddy and *aman* 20 mds/acre (1,840 kg/ha), while pure *aman* yielded 22 mds/acre (2,024 kg/ha). The correlation coefficient between the yield of *aus* and *aman* was 0.52 in *aus-aman* cropping. There is no significant difference of the yield between pure *aman* and *aman* mixed with *aus*, and therefore the yearly yield of pure *aman* fields per acre is two-thirds that of *aus-aman* fields. The yearly yield of *boro-rayada* fields seems nearly equivalent to that of *aus-aman* fields although the number of samples is not large enough to assure it.

In contrast to the *aman* cultivation, the local *boro* cultivation is only supplemental type of crop-
The yield in unhusked paddy. 1 mound = 37.2 kg

Table 2 Acreage and yield by cropping pattern (1984/85)

<table>
<thead>
<tr>
<th>Cropping Pattern</th>
<th>Cropped Acreage</th>
<th>%</th>
<th>Rice Yield per Acre* (mound)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>Variance</td>
</tr>
<tr>
<td>Aus-Aman</td>
<td>413.06</td>
<td>51.8</td>
<td>Aus 11.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aman 20.0</td>
</tr>
<tr>
<td>Pure Aman</td>
<td>160.59</td>
<td>20.1</td>
<td>Aman 22.0</td>
</tr>
<tr>
<td>Jute</td>
<td>77.44</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>Sesame-Aman</td>
<td>64.42</td>
<td>8.1</td>
<td>Aman 16.6</td>
</tr>
<tr>
<td>Jute-Aman</td>
<td>37.98</td>
<td>4.8</td>
<td>Aman 13.3</td>
</tr>
<tr>
<td>MV Boro</td>
<td>19.93</td>
<td>2.5</td>
<td>Boro 30.4</td>
</tr>
<tr>
<td>Boro-Rayada</td>
<td>6.19</td>
<td>0.9</td>
<td>Boro 15.4</td>
</tr>
<tr>
<td>Others</td>
<td>17.27</td>
<td>2.1</td>
<td>Rayada 13.0</td>
</tr>
<tr>
<td>Total</td>
<td>796.88</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

*The yield in unhusked paddy. 1 mound = 37.2 kg

Table 2 Acreage and yield by cropping pattern (1984/85)

IV. Economic Analysis of Rice Cropping Patterns

In this section, cropping patterns are evaluated by production cost analysis. Since no farmer has kept books in the village studied, calculation of the cost is roughly estimated from general information orally obtained from the farmers in the village, most of whom were owner-operators who cultivated one to ten acres by themselves. Although this estimated cost is not the actual result of any farming, nor an average, the estimation was accepted by those farmers as a reasonable one, and therefore it is adopted here as a guideline.

Production cost of aus-aman is calculated in Table 3. Three-time plowing and harrowing, including seeding during the last time, are completed with a pair of bullocks. It takes 4 to 5 man-days of labor to plow and harrow one acre of land. Wage rate in this season is TK25, which is about twice as high as that of off-season, and the hire of two bullocks costs TK20 per day. In all, land preparation takes 12 to 15 man-days and costs TK300 to TK375 of labor and TK240 to TK300 of bullocks. Hand weeding is done twice to three times and it takes 6 to 9 man-days per acre depending on the condition. This 14 to 18 man-days of weeding is added to the labor cost at the rate of TK12 per day.

Harvesting of aus requires 12 to 16 man-days per acre and post-harvest work such as threshing and drying takes 3 to 4 man-days, costing TK180 to TK240 for both. Harvesting of aman requires a little more labor: 16 to 20 man-days per acre for reaping and 6 to 8 man-days for post-harvest. In many cases of large farms, transient labor gangs are employed for aman harvesting on a share base contract. They are engaged in the operation from reaping to threshing and receive one-tenth of the
The gross yield in paddy. Usually, bullocks are again used for threshing. As they are available in the community at no tangible cost, this cost is omitted from the calculation. Items listed in the table as others cover the cost of cleaning stubbles at the beginning of dry season.

Besides those labor costs, the cost of seed is added at the rate of TK140 per mound, though the actual price of the paddy varies between TK135 and TK150 according to the season. Seeding rate per acre is 1.4 md which consists of 0.9 md of aus and 0.5 md of aman. In total, broadcast aus-aman costs TK1,420 to TK1,747 per acre, while it produces 31 mds of paddy almost equivalent to TK4,340.

As for pure aman in the lower land, costs concerning aus cropping are excluded (Table 4). Moreover because of the long term of submergence, farmers can save the cost of plowing up to two-thirds that of aus-aman, and on weeding up to a half. The seeding rate is about two-thirds, although the quantity of aman seed is doubled. As a result, the total production cost of pure aman cultivation amounts to TK920 to TK1,118 per acre. This is about two-thirds that of the aus-aman cost, but it is proportionate to the total yearly yield per acre.

In the case of boro-rayada, the growing process is quite different from that of broadcast aman (Table 5). Land preparation includes 12 to 15 man-days of making temporary bunds as well as 3 to 5 man-days of puddling with bullocks. If the field is not planted to aman in the previous cropping season, the work of piling up the straws is excluded and even the puddling is sometimes skipped. In such an extreme case, land preparation requires only 2 to 3 man-days without bullocks. And the cost of land preparation is decreased to one-tenth. Such a case is often seen in the higher fields with pure boro or boro-aus cropping patterns.

Transplanting requires 15 to 18 man-days cost-
ing TK180 to TK216 per acre, while harvesting of boro requires 23 to 26 man-days, out of which 5 to 6 man-days are saved for post-harvest. It takes 10 to 11 man-days to reap rayada and 4 to 5 man-days for post-harvest work. Costs listed as others cover the preparation of seedlings. The quantity of seed is a quarter mound, and about a half mound of urea is sometimes applied. Total production cost is TK1,220 to TK1,500 per acre, and in consequence it seems proportional to its yield, compared with aus-aman.

MV rice production in the dry season is still minor in the village studied. Of course, for years there has been some MV cultivation as double cropping in the periphery of the bil, but it was not so long ago that some farmers adopted it in place of aus-aman in the medium land. In the 1984/85 season, about 17 acres were irrigated with a low lift pump and were planted to IR 8. The pump was hired from a villager and operated by a young tenant farmer, who organized this irrigation body in 1984 with 43 other members of the village. This irrigation project was again in force in the 1985/86 season, although some tenant members were being replaced.

This fact itself may prove the advantage of MV boro over traditional aus-aman, while the three traditional rice cropping patterns of aus-aman,
Table 7 Production cost and productivity by cropping pattern

<table>
<thead>
<tr>
<th>Cropping Pattern</th>
<th>Product* (G)</th>
<th>Costs** (M)</th>
<th>(B)</th>
<th>(L)</th>
<th>(C)</th>
<th>Income per Acre (R)</th>
<th>(S)</th>
<th>(L+S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aus-Aman (a)</td>
<td>4340</td>
<td>196</td>
<td>270</td>
<td>1117</td>
<td>1583</td>
<td>2072</td>
<td>685</td>
<td>1802</td>
</tr>
<tr>
<td>Pure Aman (b)</td>
<td>3080</td>
<td>140</td>
<td>180</td>
<td>699</td>
<td>1019</td>
<td>1470</td>
<td>591</td>
<td>1290</td>
</tr>
<tr>
<td>Boro-Rayada (c)</td>
<td>3976</td>
<td>128</td>
<td>80</td>
<td>1152</td>
<td>1360</td>
<td>1924</td>
<td>692</td>
<td>1844</td>
</tr>
<tr>
<td>MV Boro (d)</td>
<td>5320</td>
<td>1194</td>
<td>260</td>
<td>1020</td>
<td>2474</td>
<td>2063</td>
<td>783</td>
<td>1803</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cropping Pattern</th>
<th>Income per Acre (R+S)</th>
<th>Labor (D)</th>
<th>Income per Man—Day (L+R+S)/D</th>
<th>Percentage of Costs (C/G)</th>
<th>(C+R)/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aus-Aman (a)</td>
<td>2757</td>
<td>3874</td>
<td>79</td>
<td>22.8</td>
<td>49.0</td>
</tr>
<tr>
<td>Pure Aman (b)</td>
<td>2061</td>
<td>2760</td>
<td>49</td>
<td>26.3</td>
<td>56.3</td>
</tr>
<tr>
<td>Boro-Rayada (c)</td>
<td>2616</td>
<td>3768</td>
<td>80</td>
<td>23.0</td>
<td>47.1</td>
</tr>
<tr>
<td>MV Boro (d)</td>
<td>2846</td>
<td>3866</td>
<td>85</td>
<td>21.2</td>
<td>45.5</td>
</tr>
</tbody>
</table>

(G): Gross product per acre in TK  (M): Material cost per acre in TK  (B): Bullock cost per acre in TK  (L): Labor cost per acre in TK  (C): Production costs per acre in TK  (R): Rent per acre in TK  (S): Operator’s surplus per acre in TK  (D): Labor per acre in man-days

* Gross product is calculated according to Table 3-1 @TK40/md.
** As for MV boro, an actual result is adopted. (see the text).

pure *aman*, and *boro-rayada* seem roughly balanced with one another in terms of production cost, it is still difficult to compare the production cost of MV *boro* in the medium land, since the results of 1984/85 season were the only case available at the time of study. At that time, the farmers’ skill in MV *boro* cultivation was not yet standardized. For example, some farmers applied only a quarter of urea per acre as done in the traditional *boro* cultivation. This resulted in a great variance of yield per acre.

From among those farmers, one successful example is shown in Table 6. This is the case of the organizer, who cultivated 0.91 acre of IR 8 on a share-cropping basis. Before the irrigation water was released, he had plowed the fields once and applied fertilizer consisting of urea, TSP⁴ and potash with a mixing ratio 2:2:1. Puddling was completed with bullocks and, after transplanting, it took three months to ripen and be harvested. In the meantime, he weeded three times and applied urea two times. The first one was applied 20 days after transplanting and the second one was 25 days after that. Then, he applied fertilizer worth TK588.

In addition, the irrigation cost was TK570 per acre and TK36 was spent for seeds. The total production cost per acre is estimated at TK2,474, out of which TK1,020 represents the labor cost. Average yield of his fields was about 38 mounds per acre (3,534 kg/ha) in paddy.

The gross product, cost and productivity of the four cropping patterns are summarized in Table 7. The concept of cost and income considered here is illustrated as follows. Gross product (G) is divided into three parts: rent (R), cost of materials (M), and the operator’s part. Since (M) is equally shared by the landowner and the share-cropper, (R) is calculated as half of [(G)−(M)]. The operator’s part consists of bullock cost (B), labor cost (L) and the operator’s surplus (S). The sum of (M), (B) and (L) is the production cost (C), and the operator’s surplus (S) is calculated as [(G)−(C)−(R)]. The income of a farmer or a landowner in various strata is as follows:

- income of a landowner: [(R)]
- income of an employed worker: [(L)]
- income of a share-cropper employing workers: [(S)]
- income of a share-cropper working himself: [(L)+(S)]
- income of an owner-operator employing workers: [(R)+(S)]
- income of an owner-operator working himself: [(R)+(S)+(L)]

Among the three traditional cropping patterns,
in terms of land productivity, pure aman cultivation is obviously at a disadvantage for any type of operator, whereas boro-rayada cropping is almost on the same level as aus-aman cropping. On the contrary, pure aman is the most profitable for the farmers in pursuit of labor productivity, or the income per day. Regarding MV boro cultivation, its productivity is similar to that of aus-aman cropping at present. Since there is enough room for improvements in the technology of cultivation, MV boro will be highly competitive with aus-aman in the future.

For example, if the irrigation charge per acre is reduced through an enlargement of the project area or due to a fall in the fuel price, or if the irrigation cost is internalized as labor cost (that is to say, if irrigation water is provided by manpower as in the traditional way), MV boro cultivation will benefit both landowners and sharecroppers irrespectively of their status. In fact, MV boro has already spread throughout Kendua Bil, or a larger bil in the same upazila. The bil is traversed by a paved road on a dike at the medium to lower level, and along the dike, a deep canal is dug and serves as a reservoir of irrigation water. The farmers easily draw the water with a swing basket to cultivate the MV boro which extends toward the central part of the bil.

Yet, this never proves absolute superiority of MV boro cultivation to traditional cropping patterns. In addition to the labor productivity, the production cost per mound also shows that pure aman cultivation would be the most efficient way of production insofar as the farmland is large enough to run a commercial production system. Actually in the village studied, the largest farming family, owing more than 120 acres and operating 92 acres with two households, cultivated 38 acres of pure aman in contrast to 20 acres of aus-aman in 1984/85. This may be an extreme and exceptional case, but it should be noted that land productivity, or income per acre, is not always the only determinative factor of cropping patterns.

V. Socio-economic Analysis of Rice Cropping Patterns

Mollarkul mouza consists of three villages. One is a Muslim village, another is a Hindu one and the other is a mixed one though separation of housing sites by religion is clear in the village. In total, there are 387 households, of which 240 are Muslims and 147 are Hindus. This distinction of religion is considerably essential to analyze socio-economic structure of a Bangladeshi village since the principle of household composition is different from each other.

As often reported, Muslims are apt to form nuclear families compared with Hindus. According to the data collected in Mollarkul, the percentage of household with only one male worker is slightly higher in the Muslims (60%) than in the Hindus (52%) (Table 8). In addition, the landlord-tenant relationship between a father and his son is often found among the Muslims, even in a household living together, while there is none of that type of tenancy among the Hindus. This shows the difference of attitude toward household budget, i.e. separation-oriented or amalgamation-oriented.

![Table 8 Number of households by religion, economic type and farm size](image-url)
On the other hand, there are few Hindu (9%) households without operating land, while nearly a quarter (24%) of the Muslim households do not have operating land. Regarding the average size of household, though there is no difference in total between the two groups, Hindu households show a wider range of variation according to the farming size to the extent that the upper class households operating over 5 acres is 1.8 time as large as the lower class. The average size of operating land per household is 1.62 acre for the Muslims and 2.12 acres for the Hindus, while 2.11 acres and 2.33 acres if excluding the households without operating land. These suggest that the middle and upper class Hindu households tend to include the family members, who would be discharged as households without operating land if they were Muslims.

Consequently, the Hindu households are more independent of each other in respect to land tenancy (Table 9). In contrast, the landlord-tenant relationship is complicatedly developed among the Muslims. It is noticeable that the greater part of the Muslim households holding over 5 acres are rather landlords than owner-operators. Three types of land tenure systems are found in the village, including share-cropping (barga), mortgage tenancy (bondak) and share-cropping of mortgaged land. In the case of typical bondak system, the mortgagor, or the original land owner, has the priority in the cultivation of his land on share-cropping basis, and the mortgagor of land can again put his right of cultivation into mortgage if he wants to borrow more money.

Out of total 797 acres operated by the villagers, 613 acres (or 77%) are owner-operated land and 118 acres (or 15%) are tenant land operated on the share-cropping basis. Regarding the mortgaged land, 51 acres (or 6%) are operated by the mortgagees while 16 acres (or 2%) are operated by the mortgagors on the share-cropping basis with the mortgagees. According to the data collected, the land price of rice fields is about TK15,000 per acre for the last five years (the average of 63 cases), and the land can be put into bondak for about TK8,000

<table>
<thead>
<tr>
<th>Table 9 Number of households by religion, land-holding and farm size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muslims</strong> Land-holding in Acreage</td>
</tr>
<tr>
<td>0 0—2 2—5 5—10 10—</td>
</tr>
<tr>
<td>Operating Land</td>
</tr>
<tr>
<td>0 acre</td>
</tr>
<tr>
<td>0—2</td>
</tr>
<tr>
<td>2—5</td>
</tr>
<tr>
<td>5—10</td>
</tr>
<tr>
<td>Over 10 acres</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10 Number of households by religion, income source and farm size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muslims</strong> Income Source</td>
</tr>
<tr>
<td>I II III IV</td>
</tr>
<tr>
<td>Operating Land</td>
</tr>
<tr>
<td>0 acre</td>
</tr>
<tr>
<td>0—2</td>
</tr>
<tr>
<td>2—5</td>
</tr>
<tr>
<td>5—10</td>
</tr>
<tr>
<td>Over 10 acres</td>
</tr>
<tr>
<td>Total (%)</td>
</tr>
</tbody>
</table>

*Income Source I: household of which the head earns income from business or service, II: household of which the head earns income from day labor, III: household of which the head earns income from only agriculture or land rent, IV: household supported by government or private relief.
Table 11 Pure aman cropped land by operators’ religion and farm size

<table>
<thead>
<tr>
<th></th>
<th>Muslims (%)</th>
<th>Hindu (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cropped Land (acre)</td>
<td>(%)</td>
</tr>
<tr>
<td>Operating Land</td>
<td>Total</td>
<td>Pure aman</td>
</tr>
<tr>
<td>less than 2</td>
<td>94.07</td>
<td>21.90</td>
</tr>
<tr>
<td>2—5</td>
<td>212.64</td>
<td>42.69</td>
</tr>
<tr>
<td>5—10</td>
<td>77.03</td>
<td>12.97</td>
</tr>
<tr>
<td>Over 10 acres</td>
<td>104.43</td>
<td>38.18</td>
</tr>
<tr>
<td>Total</td>
<td>488.17</td>
<td>115.74</td>
</tr>
</tbody>
</table>

with the term of, usually, 5 years (the average of 90 cases). TK8,000 is increased to TK15,000, or the land price, after 5 years at compound interest of 13%. Recalling that the land rent is calculated at about TK2,000 per acre (Table 7), which is equivalent to 13% of the land price, price mechanism seems to be functioning as well in the land market.

Compared with the investment in rental rickshaws or rental irrigation pumps, 13% is rather low interest in the village and the productivity of agriculture is regarded as relatively low. The percentage of the households of which the head earns income from other than agriculture is high especially among the Muslims (Table 10). This is certainly reflected on the cropping patterns. As already mentioned, pure aman cultivation is the most profitable in respect to labor productivity at present, and the Muslim farmers, especially operating 5 acres and less, allot more percentage of their land for pure aman than the Hindus (Table 11).

The distribution of labor and land mentioned above shows that the economic goal of farming seems to be somewhat different between Muslims and Hindus. That is, the Muslims who are the majority of the society have been keen to the opportunity cost even among the small landholders. That does not mean, however, a social constraint on the adoption of intensive land-use with MV boro. On the contrary, the high mobility of labor, land, and capital will make it possible to introduce modern technology of wet-rice cultivation in the future when its profitability become comparable to that of traditional cropping patterns and non-agricultural activities.

VI. Conclusions and Prospects

It can be concluded that there are no physical constraints on MV boro cultivation in the large part of the bil in this area as long as water is available during the dry season. The question really depends on economic terms, however. Since the improved irrigation method will result in the adoption of MV boro in place of aus-aman, it is a great task to reduce the water cost through the use of efficient irrigation systems or by converting it to labor cost through the use of man-power irrigation system.

Moreover, a stability in yield is also required of MVs to promote their diffusion. The cost except that of harvesting is paid in advance before the yield is fixed, and this “advanced cost” of MV boro cultivation is high compared with the traditional cropping patterns. Unless the yield becomes stable, it is risky for the farmers to adopt MV boro.

Yet, on the other hand, in the lower part of the bil where water depth exceeds 50 cm at the end of February, it is obvious that boro rice will never replace deepwater aman rice completely, whatever the variety may be, for the period is too short for boro to mature. From economic points of view, pure deepwater aman cultivation is profitable in respect to labor productivity at present, thus suggesting its prevalence among the Muslim farmers. Therefore, traditional cropping systems of deepwater rice cultivation will remain for a while.

The discussion in this article is based on a case study in the southwestern lowland where deepwater rice cultivation is dominant. In contrast, boro cultivation is major in the swampy depressions around lakes, or haors, in the northeastern districts especially in Sylhet Region (Fig. 8 and
The diagram of climates in Sylhet shown in Figure 10 is supporting this hypothesis.

This is an interesting theme in future not only in terms of cropping pattern differentiation at a national level, but also in terms of geographical variation affecting development strategy in wet-rice cultivation. Such regional differentiation at a national level should be clarified by the systematic analysis based on further spot surveys with bird's-eye remote sensing imagery over the whole region.

Acknowledgment

Fieldwork for this study was financially supported by the Grant-in-Aid for Scientific Research, Japanese Ministry of Education, Project No. 60041026. I would like to express sincere gratitude to Prof. Yoshimi Komoguchi for his ever critical comments. Thanks are extended to Prof. Tadahiko Hara and Prof. Abudlla Farouk, who gave the opportunity to participate in the overseas study. Thanks are also extended to Prof. Chauncy Harris for proof-reading of this paper. I owe also my
gratitude to Prof. Takashi YAMAGUCHI, who have
warmly seen me through my study activities for many
years.

(Received June 22, 1987)
(Received September 12, 1987)

Notes

1) They are often called as high yielding varieties,
but the author prefers to use the term modern var-
eties (MVs) because new varieties may have many
advantages other than high yielding such as flexi-
bility in planting date and location, shortening of
growth duration and so on. The term “MVs” is
used in this article to include semidwarf and inter-
mediate stature, fertilizer-responsive, mainly photo-
insensitive varieties developed since the 1960s
(BARKER and HERDT, 1985).

2) Upazila is a local administrative unit, which has
about 176 thousand of population in 1985.

3) Mouza is a cadastral unit which has a definite
boundary, whereas a gram (or a village) is a sponta-
eous settlement functioning as a primary admi-

nistrative unit. In many cases, a mouza consists of
one or more grams.

4) 1 mound=37.2 kg

5) One Taka is equivalent to 0.030 US dollar as of
January 1986.

6) Triple Super-Phosphate

7) Haors never lose water even in the end of the dry
season, while bils dry up to be cultivated.

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バングラデシュ低地部における水稲の作付体系

佐藤 哲夫

本稿はバングラデシュ低地部における水稲の作付体系の実態を土地条件および社会経済的条件の両側面から評価し、稲作技術変化の可能性について検討したものである。調査地は同国南西部の低湿地に位置するパーガルハート県モラハート郡で詳細なデータは主としてムラでの住み込み調査によって得た。この調査地はランドサット画像によりれば付近は深水田が卓越する地域に含まれる。

この低湿地は、通常小さな自然堤防によっていくつかのブロックに仕切られており、雨季には浸水するが、乾季には中央部まで干上がって耕作されている。このような湿地はビル（bil）と呼ばれている。ここでの水稲作、季節的な水位变动に対応して、収穫期の異なる稲の混植や混播、ショートやゴマとの混作を特徴としている。

慣行的な作付体系の中では、9月および11月に収穫する稲を雨季初めに混播するものが最大面積を占める。近年導入された改良品種の乾季作は、灌溉さえ整備されていれば大部分の土地で可能なので、将来は慣行的作付体系との競合が予想される。ただし生産費からみた場合には、水利費の軽減が重要な課題である。

滞水期間の長くて乾季初めに稲の移植作業を完了できないと最低位部では、危険回避のため伝統的に浮稲の単作が行われている。浮稲単作は土地集約度が低く土地生産性の点では不利であるが、稲作の回数が少なくて済むなどの理由から、労働生産性は必ずしも低くはなく、商業的経営の性格が強い経営体で作付率が高い。

減水を利用した乾季の伝統的な移植稲作の場合、種子費の節約で耕起の省略が可能となるが、仮畦作造と移植作業が加わることで、生産費の合計は混播作とはほぼ同じになる。

小作制度では収穫を折半する分益小作が一般的であった。その場合の地主の収益が実勢価格に対する比は、土地を抵当として信用小作を行った場合の利子率と均衡していることが確認された。

経営体の性格は、核家族制をとるムスリムの場合と、直系家族制をとるヒンドゥーの場合とでは異なる。前者が労働の機会費用に敏感で商業的性格をより強く示すのに対し、後者は土地貸借や兼業が少ないなど自給的性格がより強い。このような経営体の性格の違いは、水稲の作付体系にも反映しており、前者では単播浮穀の作付率が高くなっている。