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New Technologies and the Competitiveness of High- and Low-potential Rural Areas in Asia and Africa

INTRODUCTION

Three decades of the 'green revolution' in Asia amply demonstrated that the critical factor affecting the efficiency of agricultural production in the tropics is improved technology, notably fertilizer-responsive, high-yielding, modern varieties (MVs). In Asia, MVs have been adopted in irrigated and favourable rainfed environments, which may be termed 'high-potential' areas. At present, more than half of paddy area is planted to modern rice varieties in Asia. High-potential areas are relatively homogeneous, so that a single improved variety was often diffused over a wide area, suggesting that the pay-off to research tends to be high. Moreover, it is scientifically more feasible to develop rice varieties suitable for high-potential areas than for environmentally adverse low-potential zones. David and Otsuka (1994) argue that the key to the success of the 'green revolution' in Asia was a clear focus on technology development for high-potential areas, coupled with the abundant and relatively homogeneous availability of such areas in the region.

In contrast to the widespread success of the seed–fertilizer-based 'green revolution' in Asian food production, results in Africa have been mixed, despite major efforts. While hybrid maize has done well in Eastern and Southern Africa, most agricultural success stories have involved rainfed export crops. Questions have been raised about the feasibility of greatly expanding areas under irrigation in Africa, the appropriateness of Asian-type land-augmenting technological change for labour-constrained areas, the appropriateness and profitability of chemical fertilizers in continuous cropping on Africa's fragile soils, and the lack of 'miracle' varieties for food crops other than – possibly – maize and cassava suited to natural conditions of most of the continent (Lele, 1975; Anthony *et al.*, 1979; Eicher and Baker, 1982; Mellor *et al.*, 1987; Winrock International, 1991). Perhaps because of such concerns, there appears to be less emphasis for food security purposes on directing scarce research resources to the high-potential areas in Africa than was historically the case in Asia.

The thrust of this contribution is to argue that, in order to increase food production in Africa, a clearer focus must be placed on the development of technology for the high-potential areas, even though they are less widespread

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and less homogeneous than in Asia. We first review the competitiveness of rice production in selected areas of Asia in the course of the 'green revolution', and argue that the adoption of MVs and the favourable production environments conducive to their use were the decisive factors explaining differences in the competitiveness of rice production. Second, we examine the equity implications of the 'green revolution' in Asia. We argue that the inequity created by the adoption of MVs in high-potential areas in Asia was not significant, owing to interregional market adjustments, particularly migration from low- to high-potential areas. Finally, we discuss insights from the Asian experience of possible interest for agricultural development strategy in Africa.

'GREEN REVOLUTION' AND COMPETITIVENESS IN ASIA

The 'green revolution' in rice refers to the development and diffusion of semi-dwarf, fertilizer-responsive, high-yielding MVs originally bred by the International Rice Research Institute (IRRI) in the mid-1960s. Starting with the advent of semi-dwarf varieties suitable for tropical conditions, the subsequent process of the 'green revolution' has been evolutionary, involving the continuous improvement of various traits of varieties, such as pest- and disease-resistance (Jatileksono and Otsuka, 1993; Otsuka *et al.*, 1994a). Also significant have been the adaptive research efforts by national research institutions to develop varieties suitable for diverse production environments through crossing IRRI cultivars and local varieties. Such adaptive research made it possible to transfer the modern rice technology from the Philippines, where IRRI is located, to other Southeast Asian countries, and also to vastly different and generally less favourable production environments of South Asia (Hayami and Otsuka, 1994).

According to a recently completed project on the 'green revolution' in rice in Asia, the availability of physical production environments characterized by reliable irrigation water and favourable rainfed conditions decisively determined the adoption of MVs and yields.[1] Although socioeconomic factors such as farm size and tenancy are often considered critical determinants of the adoption of new technologies in the 'green revolution' literature, there is no evidence to support such views for the late 1980s (David and Otsuka, 1994) or in early years (Otsuka *et al.*, 1994a).[2]

Table 1 reports MV adoption and various measures of productivity by 'typical' production environment in selected Asian countries during the wet season in the late 1980s, based on household survey data in selected villages (David and Otsuka, 1994). Note that Lampung in Sumatra underestimates productivity in Indonesia, as the average yield per hectare in Lampung is about 30 per cent lower than in Java, the country's major rice-growing region. Even so, rainfed areas in Lampung are generally favourable compared with production environments of rainfed areas in Thailand and South Asia. Tamil Nadu represents a typically favourable rice production environment of South India, but not all of India.

MV adoption was complete in both irrigated villages and in rainfed villages in the Philippines and Indonesia, reflecting the favourable rainfed conditions

TABLE 1 *MV adoption, paddy yield, labour productivity and total factor productivity index by production environment in selected areas of Asia, wet season in the late 1980s*

Country/production environment	MV adoption (%)	Yield (t/ha)	Labour use (days/ha)	Labour productivity (kg/ha)	Total factor productivity[1]
Philippines (C. Luzon)					
Irrigated	100	4.7	83	56.6	133
Rainfed lowland	100	4.0	79	50.6	125
Indonesia (Lampung)					
Irrigated	100	4.4	178	24.7	105
Rainfed lowland	100	3.3	174	19.0	85
Thailand (C. Plain)					
Irrigated	61	3.8	58	65.3	117
Rainfed lowland	0	1.3	40	32.5	66
India (Tamil Nadu)					
Canal-irrigated	97	4.2	191	22.0	106
Rainfed-cum-tank	83	2.8	153	18.3	81
Nepal (C. Tarai)					
Irrigated	85	2.4	159	15.1	87
Rainfed lowland	5	1.9	149	12.8	77

Note: [1]Estimates of Tornqvist index, measuring divergence from logarithmic averages of output and inputs of the sample villages.

Source: David and Otsuka (1994).

commonly found in these countries. Difference in yields between the two types of environment is relatively small in those countries. The adoption rates of MVs were also high in Tamil Nadu, but the yield in the rainfed with tank-irrigated area was much lower than in irrigated regions. Yields were particularly low in the rainfed areas of the Central Plain of Thailand and Central Tarai of Nepal, where traditional varieties are grown under drought-prone rainfed conditions. Except in Nepal, where supply of irrigation water is unreliable, rice yields in irrigated areas were broadly similar across countries, suggesting relatively homogeneous production environments under well-irrigated conditions.

Labour use measured by total labour days per hectare per season was not very different between irrigated and rainfed areas within a given country. Thus the effect of MV adoption on total labour demand in favourable zones seems modest, even though its effect on the demand for hired labour was found to be significant (David and Otsuka, 1994; Otsuka *et al.*, 1994b). Also note that, because of the early-maturing and photoperiod-insensitive nature of MVs, their adoption increased multiple-cropping, resulting in higher demand for labour throughout the year. Labour use per hectare was vastly different among countries, however. It appears that this can be explained partly by differences in relative factor prices. Labour productivity was in fact low in low-wage and land-scarce countries, such as India and Nepal, and high in high-wage and land-abundant countries, such as Thailand.

In order to assess the impact of MV adoption and the effect of production conditions on overall productivity between areas within a country and across countries, a Tornqvist-type total factor productivity (TFP) index was constructed by measuring the divergence from logarithmic averages of outputs and inputs of the sample villages under the assumption of constant returns-to-scale production and competitive equilibrium. It was found that the TFP index is higher in irrigated areas than in rainfed areas, by the order of 10 to 20 per cent in each country except Thailand, where the difference is more pronounced. There were marked differences in productivity among countries. The particularly harsh geography of Nepal explains a major part of the very low productivity observed there. Differences in production conditions across other countries also seem to account for a large part of inter-country variation in productivity.

THE 'GREEN REVOLUTION' AND EQUITY IN ASIA

Widespread concern has been expressed that concentration of adoption of MVs in high-potential areas has exacerbated inequalities in the regional distribution of income in Asia; this argument is sometimes advanced to support the view that allocating greater rice research resources to low-potential regions will improve the overall distribution of income. Recent studies on income distribution in Asia, however, refute this claim (David and Otsuka, 1994).

As MV adoption increased, the demand for labour in the high-potential areas rose, and interregional migration from the low-potential areas took place. This mitigated potentially adverse distributional impacts on the poor by equalizing regional wages. Price decreases for food also helped the poor in both high- and low-potential zones, although the combination of lower prices and higher wages did not favour land owners in the lower-potential areas. Table 2 compares real wage rates, in terms of the quantity of paddy per day, in transplanting and harvesting activities between irrigated and rainfed zones in selected parts of Asia. It is clear that the wage rates are essentially similar between the two areas. This cannot be explained without interregional labour market adjustments, through both seasonal and permanent migration.

Rice yields in Asia have been largely stagnant since the late 1980s. This is undoubtedly due in part to the declining real price of rice, reflecting increased supply associated with the success of the 'green revolution'. A more important reason for stagnant yields is the progressively declining productivity of rice research. There has been no significant gain in average yield since 1980 in Central Luzon, the leading area of the 'green revolution' in Asia (Otsuka *et*

TABLE 2 *Comparison of real daily wage rates (kg/day) by production activity and environment in selected areas of Asia, wet season in the late 1980s*

Country/production environment	Transplanting	Harvesting
Philippines (Central Luzon)		
Irrigated	6.5	21.2[1]
Rainfed lowland	6.8	17.6[1]
Indonesia (Lampung)		
Irrigated	9.8	15.8[1]
Rainfed lowland	9.3	18.6[1]
Thailand (Central Plain)		
Irrigated	17.5	23.3[1]
Rainfed lowland	15.9	24.1[1]
India (Tamil Nadu)		
Canal-irrigated	4.3	5.8
Rainfed-cum-tank	5.3	8.4
Nepal (Central Tarai)		
Irrigated	4.7	4.4
Rainfed lowland	4.9	4.9

Note: [1]Imputed wage rates per day under output-sharing arrangements.

Source: David and Otsuka (1994).

al., 1994a). In Lampung, the yield gain associated with the adoption of a series of improved MVs has gradually diminished (Jatileksono and Otsuka, 1993). Furthermore, declining rice prices seem to have reduced the 'expected returns' to both rice research and irrigation investment, and have led to a marked decline in both.

A major response by farmers to declining rice prices seems to have promoted a shift to other crops, particularly in low-potential areas. This hypothesis is consistent with the difference in the relative shares of farm household income from rice production and other income sources by production environment, shown in Table 3.[3] With the exception of Thailand, the income share of rice production is substantially higher in irrigated than in rainfed areas.[4] In contrast, the share of non-rice farm income is significantly higher in rainfed areas than in irrigated areas in the Philippines, Indonesia and Nepal, whereas the share of non-farm income is substantially higher in rainfed areas than in irrigated areas in India and Bangladesh. These differences can be explained

TABLE 3 *Sources of farm household income by production environment in selected areas of Asia (%), wet season in the late 1980s*

Country/production environment	Rice	Non-rice	Non-farm
Philippines (Central Luzon)			
Irrigated	67.3	18.0	14.7
Rainfed lowland	42.6	42.6	15.0
Indonesia (Lampung)			
Irrigated	51.4	26.1	22.5
Rainfed lowland	36.1	41.6	22.3
Thailand (Central Plain)			
Irrigated	55.7	36.1	8.1
Rainfed lowland	52.9	26.7	20.3
India (Tamil Nadu)			
Canal-irrigated	51.0	45.2	3.8
Rainfed-cum-tank	42.2	25.6	32.2
Bangladesh[1]			
Irrigated	52.2	18.6	29.2
Rainfed lowland	39.3	19.2	41.5
Nepal (Central Tarai)			
Irrigated	52.4	40.9	6.6
Rainfed lowland	29.0	70.3	0.7

Note: [1]Data were collected from various parts of the country. Rainfed lowland does not include rainfed areas subject to severe drought, flooding and salinity.

Source: David and Otsuka (1994).

largely by the difference in the relative profitability of non-rice crops and the access to non-farm jobs.

Such diversification is a desirable development in rapidly growing areas of Asia, where the demands for other crops such as vegetables and feeds are increasing. Furthermore, the shift to non-rice crops in low-potential areas, which are mostly poor areas, represents an important mechanism which mitigates the regional income inequality potentially created by the differential adoption of MV technologies between high- and low-potential areas (David and Otsuka, 1994). Like migration, this helps workers in the low-potential zones, but, unlike migration, crop diversification also helps landlords.

There are basically two technology development strategies favouring crop diversification. The first is to invest in research in profitable non-rice crops. Scientific possibilities for developing new technology will generally be high, because appropriate research has been largely neglected in Asia. Unlike rice, however, other crops are diverse. Moreover, unlike irrigated paddy areas which are relatively homogeneous, low-potential production environments are heterogeneous, in that a variety of production constraints exist, including insufficient rainfall, poor drainage, micronutrient deficiencies and salinity. Thus, even if a superior variety is successfully developed, it can be diffused only in limited areas. In other words, the economic returns to research for low-potential areas will not necessarily be high (Byerlee and Morris, 1993).

Another major strategy to facilitate crop diversification in Asia is to sustain rice research for high-potential areas. Because of the homogeneity of such areas, permitting widespread replication, economic returns to research for favoured environments will be acceptable even if only a minor productivity gain is achieved. Furthermore, unless rice production in high-potential areas continues to increase, rice prices will eventually rise, which will decrease incentives to shift to non-rice crops in low-potential areas (Hayami and Otsuka, 1994). It is also important to recognize that increases in rice prices will adversely affect the welfare of the poor, who spend a large share of their household budgets on rice. Therefore continuous efforts to increase rice supply in high-potential areas are indispensable for efficient growth with equity, even though opportunities for scientific success in the development of new technologies for favourable areas are increasingly limited under conventional approaches.

High returns to research, comparable to those realized during the 'green revolution', will not be forthcoming until new advances are made by the application of biotechnology, which will be some time away. Asia now faces the challenge of achieving efficient allocation of scarce research resources to various crops, suitable for different production environments. It is important to recognize that many future research outputs will be local public goods, as specific new technologies are expected to serve only limited areas. Thus a difficult, but greater, decentralization and coordination of technology development strategy will be called for in Asia.

QUESTIONS RAISED FOR AFRICA

Insights from the Asian rice experience for agricultural development strategy in high and low crop potential areas in Africa can be organized under a series of tough questions. We specifically do not address the related and difficult issue of the transferability of technology developed in Asia to Africa, which necessarily involves complex technical issues in agricultural science that are beyond the scope of this paper. Rather, the focus is on what the Asian experience in rice tells us about the preconditions for growth in high-potential areas and the relationship of development in low-potential areas to that growth.

Can Africa's variable high-potential environments nurture a 'green revolution' in food comparable to the Asian rice story?

Two of the critical differences in the initial conditions for agricultural development between Asia and Africa lie in the degrees of homogeneity and favourableness of production environments. As shown above, irrigated paddy fields in the tropical areas of Asia present growing conditions that are relatively uniform. A single rice variety, such as IR36, was easily diffused over a wide area. The 'green revolution' in rice for Asia would not have been possible otherwise. In general, African countries lack comparably uniform growing conditions.

Furthermore, Asian MVs in rice are shorter-maturing, and 'green revolutions' generally resulted in concentration of cropping resources on a smaller number of crops. Both phenomena led to a sharper peak season demand for labour than previously, particularly in harvesting and threshing. The supply of seasonal hired labour is generally more limited in most of Africa than in most of Asia. It is possible to find alternative employment on one's own farm in less land-constrained areas, there are better opportunities for non-agricultural employment where urban bias has traditionally existed, and sharp seasonal labour bottlenecks are imposed by especially concentrated rainfall regimes in the semi-arid and savannah areas (Delgado and Ranade, 1987).

Thus it seems clear that MV food production technology, even in high-potential areas of Africa, will not follow the same path as in the relatively uniform experience across Asian rice growing areas. Yet Asian experience clearly suggests that African high-potential areas will need to be concentrated upon for 'green revolutions' to occur. However, the appropriate targets will be harder to perceive, will be more scattered, will involve a more varied cropping pattern and will involve political trade-offs to a greater extent, based on the ethnic income distribution impacts of regional priorities in Africa (Mellor *et al.*, 1987). Thus both Asia and Africa at present face difficult problems of efficient research coordination among crops, between centres and local stations, and among production environments.

Can an Asian-style 'green revolution' be led by non-food commodities in Africa?

The older model of agricultural development and commercialization in Africa emphasized progressive intensification of non-cereal export crop production: cocoa, tea, coffee, cotton, peanuts, oil palm and so forth (Anthony *et al.*, 1979; Eicher and Baker, 1982). During the colonial era, such development was in fact explicitly promoted in countries such as Senegal by the subsidized importation and distribution of cheap foodgrains from Asia (Delgado and Jammeh, 1991).

Despite the catastrophic worsening of Africa's terms of trade for agricultural exports since 1981, highly efficient pockets of export crop production have been observed where the macroeconomic policy environment did not destroy agricultural incentives as a whole and where public policy provided explicit support through infrastructure, research services and extension. The Kenya Tea Development Authority is one example (Lele, 1989). The traditionally flourishing cotton zones of Mali, Burkina Faso and Côte d'Ivoire, all of which have been in recent difficulty, are likely to regain their former vigour now that the CFA currency is devalued, and there are signs of revival in world commodity prices .

The past successes of export cropping in Africa raise the issue of the promise of further technological change in these crops for increased rural competitiveness in the region. In a fully open economy, the outlook is clearly positive, since increased demands for food from rising rural incomes generated by increases in export crop productivity can always be met by increased imports if necessary. However, in economies where very significant transfer costs apply to food imports, the economic sustainability of non-food 'green revolutions' depends on the response of marketing systems to increased food demands.

Additional food can come either from costly imports or from increased local production, depending on the specific market and production situation. Three structural characteristics of Africa stand out in this regard. First, transport and other marketing costs for importing or exporting food are typically so high that the goods concerned are not traded. For those that are, mark-ups of 100 to 200 per cent on the landed cost of grain in coastal ports are the rule in the capitals of landlocked countries. Second, a surprisingly large part of sub-Saharan Africa exhibits low substitutability in production and consumption between importable food staples, such as wheat and rice, and domestic starchy staples (Delgado and Reardon, 1991). Third, even where this is not the case, importable food staples at domestic prices yield significantly higher-priced calories than domestic staples. The implication of these three structural characteristics is that basic food staples behave essentially as non-tradeables in much of sub-Saharan Africa.

This is very different from the comparatively simple historical Asian case, where agricultural comparative advantage was clearly in foodgrain production, and the items produced (rice and wheat) were clearly tradeables on the world market. High transfer costs throughout Africa support the need for widespread 'mini-green revolutions' in local food production, as a way of reliably and cost-effectively providing food where we know it will be most needed, now and, more especially, 20 years from now. This need will be exacerbated by the additional demand provoked by rural growth from cash crop development in some locations, since rural income elasticities of demand for food staples remain high in Africa. On the other hand, local 'green revolution' successes that shift the supply curve for domestic starchy staples to the right can be expected to move the supply curve of exportables in the same direction, by lowering the costs of production of non-food exportables in terms of starchy food staples, which account for three-quarters of spending by workers and are the main 'wage-good'.

Furthermore, since they are non-tradeables, demand for food staples that is price-inelastic will lead to sharply lower local food prices and food producer incomes under a 'green revolution' in food production, as was the case in Northern Nigeria in the late 1970s. While this will shift further resources into export crop production, it will generally lead to loss of momentum in the food production change that started the process off. The strong conclusion is that the development of food and non-food sectors are complementary and mutually required in Africa's semi-open rural economies. Marketing policies that improve links between high-potential cash crop and food-producing areas are the main vehicle to take advantage of this complementarity.

What is the future for the low agricultural potential rural areas in Africa with MV technological change occurring in the high-potential areas?

The Asian survey showed that the introduction of MVs of rice in the more favourable areas of the continent did not exacerbate regional inequities in income distribution, in part because of migration from the less favoured areas to the more favoured ones, which tended to equalize wage rates across the two types of zone. Labour was better off, and land owners in unfavourable areas were worse off. However, shifts to other crops in the less favourable zones in Asia lessened the adverse equity impact of rapid growth in the more favoured areas, for both labourers and land owners at large.

In Africa, the fact that so much of the farming on the continent consists of 'owner–operator' peasant agriculture suggests that the split in interest between land owners and labour is not so sharp as in Asia, even if parts of Eastern and Southern Africa are beginning to resemble Asia in this respect. The equity impact on low-potential areas in Africa of growth in the high-potential areas is likely to be slightly different, depending on whether the initial growth impulse comes from technological change in food production or in non-food agricultural production. The impact of a growing comparative advantage in maize production, through a declining unit cost of production under technological change, will be to greatly increase the amount of maize available for sale in the production zone. Since the opportunities for cereals exports are limited in most of Africa in most years, domestic maize prices are likely to fall. The only way out of this is to facilitate the marketing of maize to less favoured zones not experiencing a maize-based 'green revolution'.

Outside drought years, attempts to strengthen marketing links between the more favourable and less favourable cereal areas have, in fact, typically run foul of marketing policies designed to maintain cereal production and producer incomes in the less favoured areas, through restriction of cereals movements. Furthermore, for less favoured areas to import more cereals from more favoured areas requires that their effective demand be growing as well, which is rarely the case in protected environments. The unfortunate result of such well-intentioned policies is to deny the longer-run benefits of the 'green revolution' in the more favoured areas to the less favoured areas through cheaper food, and to delay adjustments in production patterns necessary to keep the low-potential areas economically viable.

Increased sales of maize from more to less favoured areas will lower maize prices in the latter, but will reinforce their comparative advantage in providing other items to the more favoured zones, whose household marginal budget shares for items not traded with world markets are very high. Examples of such items would be milk, meat, fish, fruits, vegetables, local handicrafts and services. In addition to promoting better market links between the two types of zone, the focus of policy in such cases should be to facilitate supply responsiveness in the less favoured zones of those non-tradeable items most in demand in the more favoured ones. Producers in the less favoured zones would benefit from both increased sales of non-grain items and lower subsistence costs.

The main difference where cash crops lead the way is that producers in the more favoured zone are less likely to be able to supply cheaper food to those less favoured. While it is likely that the increase in agricultural productivity within the more favoured zone still includes expanding food production, as was the case in the development of the Malian and Burkina cotton areas, the zone itself is likely to absorb a large share of the additional food produced, and food prices are less likely to decline in the non-favourable areas. The latter will retain a considerable incentive to remain in subsistence food production, leading to lower net gains from diversification into non-food non-tradeable items for sale to the more favourable agricultural production areas. Even so, the more favoured areas are likely to be big net buyers of items from the less favoured zones. Of three agroecological zones surveyed in Burkina Faso, the highest total income and the lowest share of total income from farming was observed in the high-potential agricultural zone, where cotton production incomes stimulated local off-farm employment to the extent that it accounted for 39 per cent of total income of rural households sampled in the cotton zone (Reardon *et al.*, 1992). Agricultural growth in the cotton zone also generated great demand for labour, for livestock products, and handicrafts produced in the other zones.

In sum, because so much of rural Africa is 'semi-open', with domestic foodstuffs being a very imperfect substitute in both production and consumption for fully tradeable cereals, technological progress in tradeable items for the higher-potential zones will be particularly useful for inducing growth in the non-favoured areas, through trade between the two types of zone in a setting where many agricultural and non-agricultural commodities are largely protected from the world market by high transport costs. This process cannot work, however, if policies attempt to protect the lower-potential areas from progress in the higher-potential ones through trade restrictions, in effect diverting trade from the lower-potential areas away from the higher-potential ones.

The central message for rural development strategy in Africa: achieve a low relative food price

Low and stable food prices are essential for growth, welfare and food security in dynamic non-food cash crop areas, since they are the basis of rural competitiveness in non-food production. Low and stable food prices help ensure that the returns to production of the items in which rural areas have a comparative advantage are not eaten up – literally – by the cost of subsistence. In the case of high-potential food zones, farm incomes policy must be productivity-led rather than price-led. In lower-potential non-food zones, growth policy will involve facilitation of diversification into things other than crops.

Because of this, and the high cost of reliably transporting food imports to inland rural consuming areas, it is vital to identify and develop food production potential in those areas that can support a 'green revolution' thrust on food production. At the same time, policy needs to promote better marketing links in both directions with the lower-potential areas and towns, to allow them to benefit from the successes of the high-potential zones and to avoid the build-up in the latter of unusable surpluses. However, it is a mistake to try to reproduce an Asian-type 'green revolution' in low-potential areas that do not have a comparative advantage in cereals production. Growth in the latter is likely to come from growth in non-starchy staple sectors that are driven by increases in demand from the high-potential areas.

NOTES

[1]This inter-country project included the Philippines (David *et al.*, 1994), Indonesia (Jatileksono, 1994), Thailand (Isvilanonda and Wattanutchariya, 1994), Bangladesh (Hossain *et al.*, 1994), Nepal (Upadhyaya and Thapa, 1994) and India (Ramasamy *et al.*, 1994).

[2]A separate study on the efficiency of share tenancy in Asia also supports the present argument (Hayami and Otsuka, 1993).

[3]Note that the availability of irrigation water during the dry season tends to promote dry-season cropping of rice, which also increases the income share from rice production in irrigated areas.

[4]The production environment in irrigated areas of the Central Plain in Thailand is favourable not only to the production of rice but also to that of other crops, such as water chestnuts.

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