Comparative advantage of rice production in Sri Lanka with special reference to irrigation costs

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By estimating the domestic resource cost, this paper examines the changes in the comparative advantage of rice production in Sri Lanka during the last three decades. Although dramatic increases in productivity because of the Green Revolution occurred in the 1970s, rice production in the major irrigation regime has had no comparative advantage throughout the period as long as the cost of new irrigation construction is taken into account. Even if the cost of new irrigation construction is treated as a sunk cost, rice production had no comparative advantage before the Green Revolution. Within one decade after the Green Revolution, rice production became highly socially advantageous relative to rice imports because of the irrigation infrastructure. However, the comparative advantage has been eroded since the country attained self-sufficiency in rice in the mid-1980s. At present, rice production is nearly on a par with the international rice market. It has lost the comparative advantage it once enjoyed in the 1980s but it has not fallen into an overt comparative disadvantage either.

The major factor that has been pushing down the comparative advantage of rice production in recent years is the increase in the wage rate. Under the condition that it is difficult for Sri Lankan rice to find a market in world rice trade, the only option for maintaining domestic rice production that is economically sound is to increase labor productivity by pursuing economies of scale, which require significant increases in farm size. The rice sector in Sri Lanka has already entered the difficult stage of agricultural development and faces adjustment problems.

Rice has been the single most important peasant crop in many developing countries in monsoon Asia, and it has long been an important national target for attaining rice self-sufficiency in the region's traditional rice-importing countries. Thanks to massive public investments in irrigation infrastructure since the 1950s and to the technological advances in rice farming, popularly heralded as the Green Revolution, that have taken place since the late 1960s, the major rice-importing countries in South and

Southeast Asia have experienced rapid increases in rice production and have attained, or nearly attained, the rice self-sufficiency target (Barker et al 1985, Pingali et al 1997). The attainment of rice self-sufficiency and the concomitant declines in the crop's price have helped Asia's developing countries to experience rapid economic development.

How has this development process in the rice sector and the economy as a whole changed the comparative advantage of rice production in the developing countries of the Asian tropics, particularly in those that used to be rice importers? What are the future prospects for the comparative advantage of rice production in these countries? Taking Sri Lanka as an example, we try to shed light on these questions by examining the historical changes in the comparative advantage of rice production and by estimating the domestic resource cost (DRC)[1].

Definitions, data, and assumptions

Comparative advantage

According to Chenery (1961), a country has a comparative advantage in producing a good, rice in our case, if the social opportunity cost of producing a unit of rice in that country is lower than its international price. Using the concept of net social profitability (NSP) in the cost-benefit analysis, his definition can be paraphrased as follows. The social benefit of producing a unit of rice is evaluated using the shadow price. Since the shadow price of a tradable good, such as rice, is its international price, the social benefit of producing rice domestically is nothing but the amount of foreign exchange that can be earned when the country exports a unit of rice. On the other hand, the social opportunity cost of rice produced in a country is the value of domestic resources and tradable inputs that are used for producing a unit of rice, evaluated at their shadow prices. If the social benefit of rice is larger than its social opportunity cost or, equivalently, if the NSP, defined as the difference between the social benefit and the social opportunity cost, is positive, it is said that rice has a comparative advantage.

Production inputs can be classified into two groups, tradable inputs and nontradable domestic resources, and expressed in equations:

$$\begin{aligned} NSP &= B - C \\ &= P_w\,SER - (\Sigma_i^k\, a_i\, P_i\, SER + \Sigma_j^m\, b_j\, P_j) \\ &= (P_w - \Sigma_i^k\, a_i\, P_i)\, SER - \Sigma_j^m\, b_j\, P_j \qquad (1) \end{aligned}$$

[1]Two studies estimated the DRC of rice production in Sri Lanka: Edirisinghe (1991) and Shilpi (1995). The results of their estimations are in contrast: the former indicates some comparative advantage, whereas the latter insists upon no comparative advantage at all. A common defect in these two studies is that they used data obtained at one time point. This is a particular problem in the DRC estimation of agricultural crops that exhibit great varieties in yields over time. Such is the case of rice in Sri Lanka. One time-point estimate also makes it difficult to know the direction of change in comparative advantage over time. We try to overcome these defects by dealing with a long-term trend in rice production.

where NSP = net social profitability of producing a unit of rice, B = social benefit of producing a unit of rice, C = social opportunity cost required to produce a unit of rice, P_w = international price of rice in foreign currency, SER = shadow exchange rate, a_i = input coefficient of ith tradable input to produce rice, P_i = shadow price of ith tradable input in foreign currency, b_j = input coefficient of jth domestic resource to produce rice, and P_j = shadow price of jth domestic resource.

Rice production has a comparative advantage when

$$B > C, \text{ or } P_w \, SER > (\Sigma_i^k a_i P_i \, SER + \Sigma_j^m b_j P_j).$$

Now, define a SER such that NSP = 0. Denoting the SER satisfying this condition as SER*, we obtain from equation 1

$$SER^* = \frac{\Sigma_j^m b_j P_j}{(P_w - \Sigma_i^k a_i P_i)} \quad (2)$$

This SER* is called the domestic resource cost (DRC). From equations 1 and 2, it is obvious that, if SER > SER* and NSP > 0, rice production has a comparative advantage. More conveniently, obtaining the resource cost ratio (RCR) by dividing DRC by SER, rice production has a comparative advantage if RCR < 1.

By totally differentiating equation 1, we obtain

$$d(NSP) = SER[d(P_w) - \Sigma_i^k P_i \, d(a_i) - \Sigma_i^k a_i \, d(P_i)] + (P_w - \Sigma_i^k a_i P_i) \, d(SER) - \Sigma_j^m P_j \, d(b_j) - \Sigma_j^m b_j \, d(P_j) \quad (3)$$

The sources of change in comparative advantage for a certain period can be assessed by inserting the respective variables into equation 3. The NSP, that is, the comparative advantage, is improved when the international price of rice and/or the SER rise. It is also improved when the international prices of tradable inputs, such as commercial fertilizers, and/or the shadow prices of domestic resources, such as labor, fall. Technical changes that decrease the input coefficients help the NSP improve.

Costs of rice production[2]

The data needed to identify changes in the input coefficients (a_i and b_j) in rice production over time are obtained from the cost of cultivation of agricultural crops (CCAC) compiled by the Department of Agriculture from 1978-79 to now. Since this series reports the costs of rice production by irrigation regime, the "major irrigation" regime and the "rainfed" regime, the DRC is estimated for these two regimes separately[3]. Selecting four districts for the major irrigation regime and two districts for the rainfed

[2] See Kikuchi (2000) for more details on rice production costs used in this paper.

[3] There is a third regime, the "minor irrigation" regime, whose rice production cost data are not sufficient for making a reliable estimation.

regime,[4] we first estimate input coefficients by district and by regime and then aggregate them to the major irrigation regime and the rainfed regime at the national level using the area sown to rice as a weighing factor. To even out short-term fluctuations in production and prices, the estimation is based on five-year averages centering on four time points, 1980, 1985, 1990, and 1995. Since the cost structure differs little between the maha (the northeast monsoon) season and yala (the southwest monsoon) season, the average of the two seasons is used in the analysis.

The CCAC data cover the years of the post-Green-Revolution period. To extend our data series to the years of the pre-Green-Revolution period, we use the data on rice production costs collected by Jogalatnam et al (n.d.) in nine major irrigation schemes for the 1967-68 maha season. To overcome the difficulty arising from a single-season survey, of the nine schemes, we select five as "typical" major irrigation schemes of normal-year conditions. For the major irrigation regime, therefore, the DRC is estimated for 1968 in addition to the above four years.

Prices

There is a consensus that the quality of rice produced in Sri Lanka is roughly equivalent to Thai 25% broken (Edwards 1993, Shilpi 1995), so we take the Colombo C&F equivalent of the FOB price at Bangkok of Thai 25% broken as the border price of rice (P_w). The shadow prices of tradable inputs (P_i) are estimated by applying the respective implicit tariff/subsidy coefficients to the domestic prices. The implicit tariff/subsidy coefficient of urea is obtained by estimating its border price based on its FOB price in Europe, then adjusting for freight and insurance. The same tariff/subsidy coefficient is assumed for other fertilizers. For seed paddy, the nominal protection coefficient for rice is used as the implicit tariff/subsidy coefficient. For the rest of the tradable inputs, the implicit tariff/subsidy coefficients used by Shilpi (1995) are adopted. For all the tradable inputs, their domestic components are estimated by adopting their percentage shares used by Shilpi (1995). Edirisinghe (1991) is also referred to on these aspects to check the reliability of the data used by Shilpi (1995).

The domestic (nontradable) resources used in rice production are labor, buffalo, land, and the interest earned on funds used in the production process. For labor inputs and buffalo service, the market prices are taken as their shadow prices (P_j). In other words, we assume that the markets for these domestic resources are working reasonably well.[5] No price data are available for land and capital interest in the cost of

[4]The four sample districts selected for the major irrigation regime are Polonnaruwa, Kalawewa, Kurunegala, and Hambantota, and the two sample districts selected for the rainfed regime are Kurunegala and Galle.

[5]Symptoms of high unemployment rate in the rural areas, however, suggest the opposite. One may wonder if the assumption of well-working rural labor markets in Sri Lanka is tenable. Recent World Bank studies (World Bank 1995, 1996), however, find that the rural labor markets function far better than traditionally expected. There are some signs, besides those mentioned in these studies, that indicate a rapid integration of rural labor markets into the national labor market in recent years. For example, the variation of wage rates in rural labor markets across different regions, which used to be large until the early 1990s, has decreased significantly in recent years. In terms of five-year averages, the coefficient of variation (CV) of agricultural wage rates among the sample districts taken for our study was as high as 18% in 1990, but declined to a mere 8% in 1995. The CV was 18% in 1980 and 16% in 1995. Therefore, we do not make such an assumption as the shadow price of labor being 60% of the market wage rate, the assumption made by Edirisinghe (1991) based on the convention adopted by the National Planning Division of the government.

production surveys used in this study. It is hazardous to estimate the shadow price of land devoted to rice production, partly because of the paucity of available information and partly because of the malfunctioning land market. In this study, we try to evaluate the shadow value of land service by the factor share of land in rice production estimated as the residual after subtracting the nonland costs from the output value. The residual is supposed to consist of the returns to land and farmers' management, and profit. The residual represents the upper bound of returns to land, as long as the nonland costs are valued properly and the profit is close to zero as is supposed to be so in the long-run equilibrium. Following Shilpi (1995), the interest rate in rural areas is assumed to be 30% per year.

Shadow exchange rate

The shadow exchange rate (SER) is another variable hazardous to determine. Bhalla (1991) estimates that the official exchange rate (OER) was overvalued by 15% for 1966-70. For the 1980s and 1990s, Shilpi (1995) estimates that the OER was overvalued by 16% in the early 1980s and by 10% in the early 1990s. Edirisinghe (1991) assumes a 10% overvaluation of the OER around 1990 based on information from the National Planning Division. On the basis of these studies, let us assume 16% overvaluation for 1968, 1980, and 1985 and 10% for 1990 and 1995.[6]

Irrigation costs[7]

Irrigation has been the most critical factor determining the productivity of rice production in Sri Lanka. Considering its importance, we estimate the DRC for the major irrigation regime by four different levels of irrigation costs: (1) operation and maintenance (O&M) cost alone, (2) cost for new system construction and O&M cost, (3) cost for major system rehabilitation and O&M cost, and (4) cost for water management improvement with minor rehabilitation and O&M cost.

The cost of O&M for major irrigation systems is assumed to be Rs 1,800 (US$ 35.10) ha^{-1} in 1995 prices, the level the Irrigation Department sets as the "desired level" of O&M expenditure ha^{-1} for the major irrigation systems. It is assumed that this level of O&M activities can be carried out by using domestic resources. The cost of new irrigation construction is obtained based on the unit capital cost curve estimated from actual construction data.[8] For the cost of major irrigation rehabilitation, the unit cost of the Irrigation System Management Project (ISMP) implemented for 1987-92 is assumed. Among all the major rehabilitation projects implemented thus

[6] It should be noted that the rate of currency overvaluation might have been higher than assumed here. Thorbecke and Svejnar (1987), for example, assume the rate of overvaluation on the order of more than 100% for the late 1960s based on the black-market exchange rate.

[7] For details on the estimation of public irrigation costs, see Kikuchi et al (2001a).

[8] The capital cost curve used is as follows: Ln K = −106.3 + 0.0569 t, where K = capital cost ha^{-1} of new irrigation construction in 1995 prices (in Rs 000) including capital interest (10% y^{-1}) and t = time in years (Kikuchi et al 2001a).

far in Sri Lanka, the ISMP gives the least unit rehabilitation cost. The cost of minor rehabilitation is assumed to be the average of the two water management improvement projects with minor physical rehabilitation analyzed in Aluwihare and Kikuchi (1991).

For all these investment costs, the capital cost is annualized by applying the interest rate of 10% that is widely applied in this kind of study. The GDP implicit deflator for construction is used for all types of irrigation expenditures to convert the costs in constant prices to those in the years under study. The multiple cropping ratio of 1.4, the average for the major irrigation systems after 1980, is assumed for all types. Irrigation projects use traded as well as nontraded goods. The percentage share of traded goods in the total costs is assumed to be 7% for the new construction project and 27% for the major rehabilitation project, based on Shilpi (1995). The same share as for the major rehabilitation is assumed for the minor rehabilitation. Evaluation by shadow prices of these tradable goods used in the irrigation projects is made by applying the implicit tariff rates assumed in Shilpi (1995): 0% for the new construction and 20% for the major rehabilitation project.

In addition to the four levels above, which are all public investments/expenditures, we try to estimate the DRC with farmers' private investments in tubewells and pumps to irrigate their paddy fields in major irrigation schemes. The costs of tubewells and pumps are obtained from Kikuchi et al (2001b). Since these wells and pumps operate in major irrigation schemes, the O&M cost is added to their costs. Because of data limitations, the DRC estimation for this case will be made only for 1995. With water from tubewells and pumps in addition to surface water, rice yield is assumed to be 15% higher than without these facilities.

Development of rice production

The dramatic development of rice production in Sri Lanka over the last five decades can best be demonstrated by the changes in the rate of self-sufficiency in rice (Table 1 and Fig. 1). Just after independence in 1948, the country produced only 36% of the total rice requirement. In the mid-1990s, the rate of self-sufficiency was more than 90% and rice was even exported in some years. Sri Lanka has been enjoying virtual self-sufficiency in rice for the last two decades. For the national policy target of attaining rice self-sufficiency, Sri Lanka has achieved remarkable success.

Before and during the Green Revolution

Increases in rice production had been particularly rapid until 1980 (Table 1). This rapid development was due to the development and diffusion of the new rice technology. Unlike other countries in the Asian tropics where the Green Revolution in rice began in the late 1960s with the release of IR8 from the International Rice Research Institute in the Philippines, the seed-fertilizer revolution in Sri Lanka commenced much earlier—in the 1950s (Anderson et al 1991). Improved rice varieties (H series, called old improved varieties) were locally developed and began to be diffused in the late 1950s, and another series of improved varieties (BG series, called new improved

Table 1. Selected statistics on the rice sector in Sri Lanka, 1950-95.[a]

Year(s)	Paddy yield ($t\ ha^{-1}$) (1)[b]	Paddy harvested area (000 ha) (2)	Paddy production (000 t) (3)	Rice imports (000 t) (4)	Rice exports (000 t) (5)	Rice self-sufficiency rate (%) (6)[c]	Per capita rice consumption (kg) (7)[d]	MV ratio (%) (8)[e]	Nitrogen per ha (kg) (9)
1950	0.90	399	360	649	0	36	90	0	1
1960	1.58	547	864	739	0	54	109	13	12
1970	2.11	667	1,409	523	0	73	104	68	45
1980	2.56	807	2,065	271	3	89	107	87	82
1990	3.11	760	2,362	306	0	89	105	92	116
1995	3.12	791	2,473	244	23	92	100	96	136
Growth rate (% y^{-1})									
1950-60	5.8	3.2	9.2	1.3	–	4.2	1.9	–	27.8
1960-70	2.9	2.0	5.0	–3.4	–	3.1	–0.4	18.1	14.2
1970-80	1.9	1.9	3.9	–6.4	–	2.0	0.2	2.6	6.2
1980-90	2.0	–0.6	1.4	1.3	–16	0.0	–0.1	0.5	3.4
1990-95	0.1	0.8	0.9	–4.5	119	0.7	–1.0	0.8	3.3

[a]Five-year averages centering on the years shown, except for 1950. For 1950, 1949-51 average for (1) – (7) and 1950-51 average for (8) – (9). [b](1) = (3)/(2). [c](6) = (3)/[(3) + (4) – (5)]. [d](7) = [(3) + (4) – (5)]/population. [e]The ratio of area planted with improved rice varieties (old and new) to total rice planted area.
Sources: See Aluwihare and Kikuchi (1991) except for (5). The data on rice exports are from FAOSTAT.

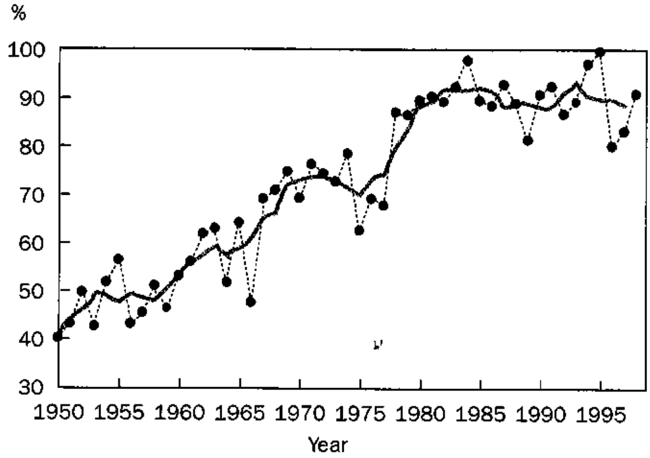

Fig. 1. Changes in rice self-sufficiency in Sri Lanka, 1950-98.

varieties), also locally developed, followed the old improved varieties after a decade. The diffusion of this Sri Lankan version of MVs and the corresponding increase in fertilizer intensity brought about rapid improvements in rice yield per hectare (Table 1).

Even more important than the Green Revolution technology for the dramatic increase in rice production in Sri Lanka has been the development of irrigation infrastructure since independence (Thorbecke and Svejnar 1987, Aluwihare and Kikuchi 1991). In pursuit of rice self-sufficiency, massive investments had been made toward the mid-1980s by the government, with more and more foreign assistance in later years, to renovate ancient tank systems abandoned in the medieval era and to construct new irrigation systems in the dry zone.[9] As shown in Figure 2, the share of irrigated area in the total area planted to rice increased from about 45% in the early 1950s to more than 70% in the mid-1990s. Particularly distinct was the significant increase in rice planted area irrigated by major irrigation schemes (schemes with a command area of more than 80 ha). It was on this irrigated land base that the Green Revolution technology was successfully introduced and diffused. At present, the irrigated rice planted area of about 70% produces nearly 80% of the country's total rice output.

Changes in input intensities in rice production by irrigation regime, estimated from the Jogalatnam and CCAC surveys, are presented in Table 2, together with land,

[9] The irrigation sector took nearly 40% of the share in the total public investments around 1950, and the share was still as high as 20% around 1980 (Aluwihare and Kikuchi 1991).

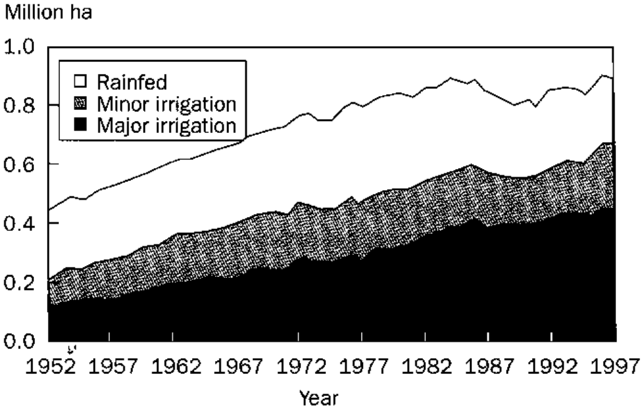

Fig. 2. Area planted to rice by type of irrigation regime in Sri Lanka, 5-year moving averages, 1952-97.

labor, and total factor productivities. For the major irrigation regime, major changes in rice production structure occurred from 1968 to 1980. The intensities of fertilizer and chemical inputs increased significantly. In that time, major rice varieties changed from traditional and old improved varieties to new improved varieties. The increases in fertilizer and chemical intensities reflect the nature of fertilizer and chemical use by the new improved varieties. Labor inputs per ha of planted area also increased about 40% from 1968 to 1980, suggesting the labor-absorbing nature of the seed-fertilizer technology. The effect of this technological change in rice farming on productivity was also substantial. Rice yield per ha (land productivity) increased by nearly two times and labor productivity improved in spite of the increase in labor intensity. Altogether, the total factor productivity increased by more than 60% in this period.

After the Green Revolution

The change of pace in the development of the rice sector after the virtual attainment of rice self-sufficiency in the mid-1980s is apparent. Though still increasing, growth in rice production has apparently decelerated since then (Table 1). This deceleration coincided to a large extent with the exhaustion of the yield potential of the Green Revolution technology. The land area planted to rice began to decrease in the mid-1980s (Fig. 2).

The deceleration in land productivity growth for the major irrigation regime in the 1980s and '90s is obvious (Table 2). Fertilizer intensity continued to increase, but only marginally, and so did rice yield per ha. All this suggests that the yield potential of the seed-fertilizer technology had been exhausted by the early 1980s. On the other hand, some non-yield-increasing technical changes occurred. Most notably, land preparation by draft power was rapidly replaced by two-wheel tractors, which accompanied the substitution of capital services for labor. The quantity of seed paddy per ha showed a slightly increasing trend, reflecting the gradual shift in the method of crop establishment from transplanting to direct seeding. Since direct seeding requires less

Table 2. Rice yield, input intensities in rice production per ha of planted area, and productivities, Sri Lanka, 1968-95, by irrigation regime, averages of maha and yala seasons.[a]

Year	Rice yield (t)	Input intensities								Labor productivity (kg d^{-1})	Total factor productivity (index)
		Current inputs				Capital[e]			Labor (d)		
		Seed (kg)	Fertilizer[b] (kg)	Chemical[c] (L)	Fuel[d] (gal)	Buffalo (h)	2-wheel tractor (h)	4-wheel tractor (h)			
Major irrigation											
1968	2.00	103	172	0.2	10.6	156	0.0	6.0	102	20	61
1980	3.75	111	377	2.5	7.2	250	3.6	5.3	144	26	100
1985	4.04	116	382	2.5	5.9	138	17.5	4.3	130	31	111
1990	4.23	116	386	2.8	9.2	68	31.8	4.8	125	34	114
1995	4.44	128	422	2.9	11.6	3	37.2	5.0	107	42	123
Rainfed											
1980	2.65	104	380	1.7	1.2	174	3.0	0.7	129	21	100
1985	2.73	106	293	1.2	2.1	101	7.6	1.4	130	21	102
1990	2.60	113	277	1.6	4.4	116	11.1	2.9	116	22	95
1995	2.84	123	319	2.0	6.0	41	15.9	3.2	108	26	106

[a]Based on five-year averages centering on the years shown except for 1968. Estimated from the Cost of Cultivation of Agricultural Crops except for 1968. For 1968, from Jogalatnam (n.d.). [b]Simple summation of V-mix, urea, TDM, and other minor fertilizers. [c]Pesticides and herbicides in adzorin equivalent. [d]In diesel equivalent. [e]Sprayer services are included for 4-wheel tractor.
Source: Kikuchi (2000).

labor input, this technical change also contributed to reducing labor intensity. Underlying the adoption of these labor-saving techniques was the rise in agricultural wage rate relative to rice price and capital rental rates during the 1980s and '90s (Fig. 3). As a result, labor productivity grew much faster than land productivity, whereas the rates of improvements in total factor productivity were in between.[10]

The most notable change in the post-Green Revolution period is the decline in rice price (Fig. 4). In the international rice market, as the Green Revolution technology was adopted successfully in the developing countries in Asia starting in the late 1960s, the rice price in real terms peaked in the mid-1970s in terms of five-year moving averages, declined by the mid-1980s to a historic low level, and has shown no upward trend since then. The domestic rice price followed the world price, but the degree of decline was higher than that of the world price because of higher nominal protection rates in earlier years until the late 1970s. It is consumers who have received the benefits of the productivity increase in rice production in the form of a consumer surplus, in addition to the income transfer resulting from the reduction in the rate of protection for rice farmers.

Another important change that the rice sector in Sri Lanka faces is that consumers have been reducing their per capita consumption of rice since the mid-1980s (Fig. 5). During the early 1990s, rice tended to be replaced by wheat in food consumption, but,

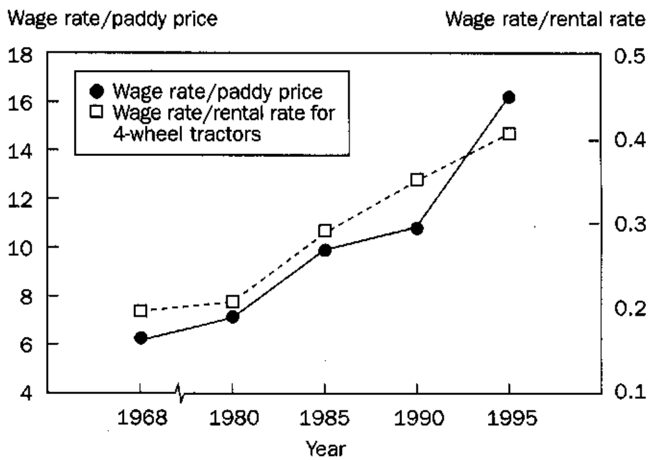

Fig. 3. Changes in real wage rate deflated by paddy price and wage-rental ratio, rice sector in Sri Lanka, 1968-95.

[10] For the rainfed regime for which data are available only for 1980 and thereafter, there was no significant change in rice yield per ha. Fertilizer intensity was highest in 1980 when the fertilizer-rice relative price was lowest because of heavy fertilizer subsidies around that year. As in the major irrigation regime, the substitution of capital services for labor through tractorization and the labor saving from the gradual diffusion of direct seeding progressed. As a result, labor productivity improved, particularly in the 1990s, when increases in wage rate relative to rice and capital prices became more distinct. In terms of total factor productivity, however, rainfed rice farming has experienced little improvement in the last two decades.

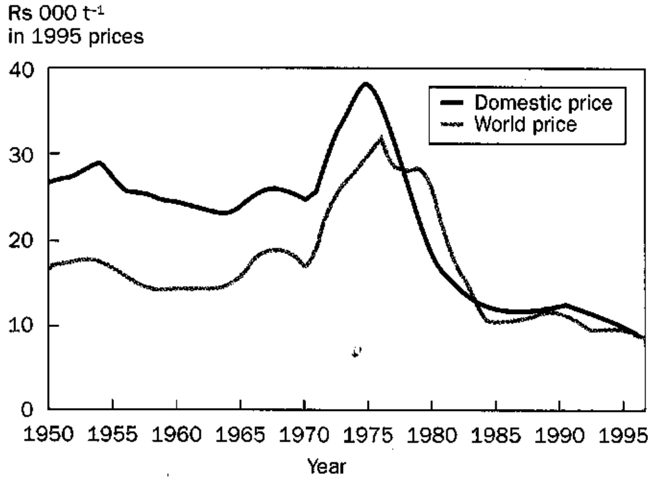

Fig. 4. World price (Colombo C&F price of Thai 25% broken) and domestic price of rice in Sri Lanka, deflated by gross domestic product deflator (1995 = 1), 5-year moving averages, 1950-97.

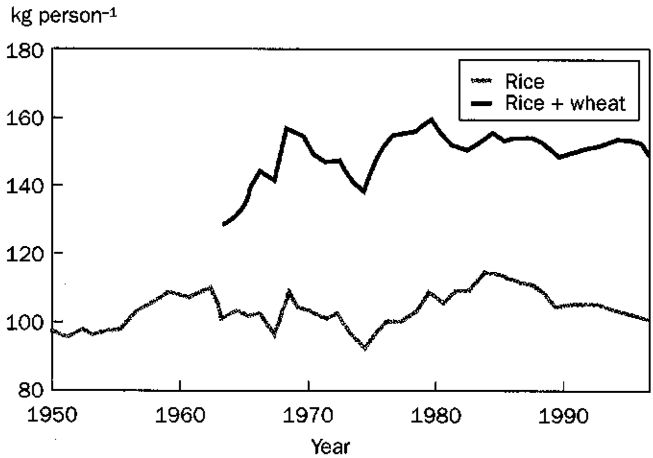

Fig. 5. Per capita consumption of rice and wheat in Sri Lanka, 5-year moving averages, 1950-96.

in recent years, the sum of rice and wheat consumption per capita has been declining. With a declining trend in per capita rice consumption, the overproduction of rice has been a real danger since 1990.[11]

The changes in the nominal protection rate (NPR) for rice shown in Figure 4 indicate changes in the policy stance of the government toward the rice sector. The

[11]Sri Lankan rice is said to have quality that does not find a large demand abroad. If so, overproduction of some significant extent may create serious pressure in the domestic rice market.

NPR had been as high as 50–70% until the mid-1970s, suggesting a heavy bias toward protection in the government rice price policy. Around 1980, the rice sector was in the final approach in attaining self-sufficiency in rice and the government kept its traditional stance of boosting domestic rice production and protecting rice farmers by extending heavy subsidies for fertilizer and irrigation development, most notably the Accelerated Mahaweli Development Project. As the virtual self-sufficiency in rice was attained and the world rice price declined to the historic low level in the mid-1980s, the NPR became insignificant and has remained so thereafter. The fertilizer subsidy was given to rice farmers, but it was abolished in 1991 after the rate of subsidy had been reduced. It was restored again in 1994 by the new center-left government, but the rate of subsidy has been around 15%, much lower than the 40–70% in the 1970s and '80s.

Changes in comparative advantage

The estimated domestic resource cost (DRC) and resource cost ratio (RCR) are presented in Table 3 by irrigation regime, together with the shadow exchange rate (SER). For rice production in the major irrigation regime, the estimation takes only O&M cost into account. Since the assumed level of O&M is the "desired level" with which major irrigation schemes are expected to sustain their operation for the designed usable life span of 50 years, we treat this as the basic case for the major irrigation regime.

It is estimated that the RCR for rice production in the major irrigation regime declined from 1.15 in 1968 to 0.58 in 1980, that is, rice production did not have a comparative advantage just before the adoption of the new improved varieties and associated seed-fertilizer technology, but, as the Green Revolution technology reached a high diffusion level, rice production turned out to have a comparative advantage later.[12] However, the comparative advantage diminished again toward 1990 and the RCR has been at about the breakeven level in the 1990s.

For the rainfed regime, data are available only in and after 1980. It is interesting to observe that, in spite of the much lower level of productivity, the level and trend of the RCR of the rainfed regime have been similar to those of the major irrigation regime. As a result, the RCR for the country as a whole, obtained by aggregating the RCR of these two regimes while assuming the average for the minor irrigation regime, followed more or less the same pattern as the major and rainfed regimes. For the rainfed regime and for the country as a whole, the RCR was far less than unity in 1980, increased but was still less than unity in 1985, increased to the breakeven level in 1990, and stayed nearly constant since then.

[12] As explained earlier, the rate of adoption of old improved varieties (H series) that had been diffused since the late 1950s exceeded 50% by the late 1960s. The finding here suggests that the actual productivity effect of this H series was not as high as that of the new improved varieties (BG series) that began to be diffused in the late 1960s.

Table 3. Domestic resource cost (DRC), shadow exchange rate (SER), and resource cost ratio (RCR) of rice production by irrigation regime, Sri Lanka, 1968-95.[a]

Year	DRC (1)	SER[b] (2)	RCR (1)/(2)
Major irrigation[c]			
1968	7.4	6.4	1.15
1980	11.9	20.4	0.58
1985	26.2	31.0	1.85
1990	41.3	42.5	0.97
1995	56.0	57.9	0.97
Rainfed			
1980	12.0	20.4	0.59
1985	30.7	31.0	0.99
1990	44.7	42.5	1.05
1995	55.7	57.9	0.96
All country[d]			
1980	11.9	20.4	0.59
1985	28.1	31.0	0.91
1990	42.6	42.5	1.00
1995	55.9	57.9	0.97

[a]Five-year averages centering on the years shown. Average of maha and yala seasons. [b]Assumes 16% overvaluation in the exchange rate in the 1980s and earlier and 10% overvaluation in the exchange rate in the 1990s. [c]The ideal level of operation and maintenance expenditure is included as cost (Rs 1,828 ha^{-1} y^{-1} in 1995 prices). [d]Aggregated using the rice production in each regime as weights, while assuming the average of the two regimes for the minor irrigation regime.

Since the DRC estimates are subject to an unknown degree of statistical error, we have to be careful in drawing some conclusions from the results. However, for the periods in and after 1980 for which data are relatively more reliable, it would be safe to conclude that rice production in Sri Lanka definitely had a comparative advantage around 1980. The advantage has been eroded in the last two decades, but the rice sector does not face an overt comparative disadvantage yet. It may be worth emphasizing that rice production in the major irrigation regime that shares about 70% of the total rice production of the country is still socially profitable, as long as the investment costs of constructing these major irrigation schemes are treated as sunk costs.

Our results suggest that rice production had no comparative advantage before the diffusion of Green Revolution technology based on the new improved varieties began in the late 1960s. With the SER that was lower than the OER by 16%, the RCR in 1968 is estimated to be 1.15. It should be remembered that the reliability of data for 1968 is weaker than for the years in the 1980s and '90s. In particular, the RCR depends critically on the rate of overvaluation of the OER. To the extent that the overvaluation had been larger than the level we assume, the RCR would have inched down toward unity, and, for the rate of overvaluation larger than 34%, it turns out to be less than unity. However, these results, coupled with the fact that the nominal protection rate for rice was extremely high in the 1950s and '60s, seem to be suffi-

cient to support our conjecture that, in the earlier years before the advent of the Green Revolution technology, rice production in Sri Lanka used to have a comparative disadvantage, but this situation improved significantly toward 1980.

How are the conclusions for the major irrigation regime modified, if other costs of irrigation are taken into account, in addition to the O&M cost? Table 4 presents the results of an RCR estimation that incorporates the cost of new construction/rehabilitation of major irrigation schemes. The cost of new construction refers to the investment costs for constructing new major irrigation schemes. New irrigation construction projects in Sri Lanka began just after independence at relatively easier sites and moved to more difficult ones (Aluwihare and Kikuchi 1991). The cost escalation of new construction involved in this process is reflected in our estimation.

As mentioned earlier, a newly constructed irrigation scheme is expected to continue its operation for several decades, if it is operated and maintained adequately. As in other developing countries, however, the O&M of these irrigation schemes has rarely been adequate, resulting in rapid deterioration in their quality and performance after their construction. Irrigation rehabilitation aims at restoring the quality of deteriorated schemes, or modernizing them, to a level higher than the original design. Rehabilitation projects can be grouped into two depending on their emphasis: major rehabilitation if the emphasis is more on improving the physical structures of irrigation schemes requiring higher unit project costs and minor rehabilitation if the emphasis is more on improving the management or institutional aspects of irrigation schemes requiring lower unit project costs. Since the need for these rehabilitation projects arose in and after the 1970s, in Table 4 the RCR estimates with the rehabilitation cost are given for 1980 and thereafter.

The inclusion of the new construction cost increases the RCR of rice production in the major irrigation regime drastically. Except 1980, when the RCR became closer to unity, throughout the period under study, it has far exceeded the breakeven level. This finding suggests that new irrigation construction in Sri Lanka has not been justified economically from the comparative advantage point of view since three decades

Table 4. Resource cost ratio of rice production under the major irrigation regime by type of irrigation investment, Sri Lanka, 1968-95.[a]

Year	O&M[b]	New construction[c]	Rehabilitation[d] alone	
			Minor	Major
1968	1.15	1.79	–	–
1980	0.58	1.11	0.59	0.62
1985	0.85	2.53	0.87	0.94
1990	0.97	3.46	1.00	1.07
1995	0.97	4.99	1.00	1.08

[a]Assumes overvaluation in the exchange rate of 16%, 16%, and 10% for 1968, the 1980s, and the 1990s, respectively. Five-year averages centering on the years shown. [b]O&M = operation and maintenance, with the ideal level of O&M expenditure. [c]The cost of constructing new irrigation systems in addition to O&M. [d]The cost of rehabilitating irrigation systems in addition to O&M.

ago or even earlier. This statement is unambiguously accepted for the years since the mid-1980s. With the escalation in investment cost for new irrigation construction in recent decades, particularly after the Accelerated Mahaweli Project began (Kikuchi et al 2001a), it is impossible to justify any large-scale new irrigation construction project as long as the new scheme is meant for rice production alone as before.

Likewise, the statement appears to be maintained with certainty for the 1960s and earlier. The RCR in 1968 is estimated to be 1.79 under the assumption that the exchange rate was overvalued by 16%. Even if we adopt the overvaluation rate of 100%, the RCR is still more than unity. Another sensitivity test may be to substitute the new construction cost of 1950 for that of 1968 in the DRC estimation. With the 1950 cost, which is less than one-third of the 1968 cost in real terms, the RCR is still as high as 1.4 under the assumption of the overvaluation rate of 16%. Combining this with the fact that the world rice price in the late 1960s was at its highest peak in the last four decades (Fig. 4), it is highly unlikely that rice production in the major irrigation regime, if the cost of new irrigation construction is included, had a comparative advantage in the 1960s and earlier.

The RCR being 1.11 under the same assumption, whether rice production in the major irrigation regime had a comparative advantage around 1980, the heyday of the Green Revolution, is debatable. One could argue that an 11% excess over the breakeven level would be well within a possible error margin. One might also claim that, before the Accelerated Mahaweli Project that accelerated the increase in the cost in the 1980s, the new irrigation construction cost should have been much lower in the 1970s. The sensitivity test of substituting the construction cost of 1970 into the DRC estimation for 1980 gives an RCR estimate of 0.88, confirming that rice production in the major irrigation regime under the conditions prevailing in 1980 with the new irrigation construction cost of the pre-Mahaweli level has a comparative advantage.[13]

These evidences may not be sufficient to conclude that the Green Revolution in the 1970s changed the position of rice production in the major irrigation regime in Sri Lanka from a traditional comparative disadvantage to a comparative advantage even for the case including the cost of new irrigation construction. It is certainly the case, however, that the traditional comparative disadvantage decreased significantly around 1980 and, if rice production with the construction of major irrigation schemes had ever had a comparative advantage in its history, it should have been in this period.

The inclusion of the minor rehabilitation cost in addition to the O&M cost changes the level of RCR little. Therefore, there is no need to alter the conclusion derived from the RCR series with the O&M cost alone: as long as the new irrigation construction cost is treated as a sunk cost, the social profitability of rice production with minor rehabilitation, which was high in 1980, has eroded to a level at par between domestic production and imports. The addition of the major rehabilitation cost gives a similar result, though the RCR increases to a level slightly more than unity in the 1990s.

[13]The same exercise with the new irrigation construction cost of 1975 gives an RCR of 0.98.

It should be remarked that the major rehabilitation cost assumed in this paper is taken from a major rehabilitation project that had the lowest unit rehabilitation cost among all the major rehabilitation projects implemented thus far in Sri Lanka. All other major rehabilitation projects had a unit cost 50% to 250% higher than the assumed level. This means that rice production in the major irrigation regime with major rehabilitation has no comparative advantage at present and that, with an increasing trend in the RCR, the situation will get worse in the future. The desired level of O&M maintains the major irrigation schemes for decades, but it is the major rehabilitation projects that make the reproduction of the existing irrigation schemes in the long run possible. Our findings imply that, with the present level of rice technology, rice production in the major irrigation regime, while rehabilitating the major irrigation schemes, will entail a net social loss to the country unless the efficiency of the major rehabilitation projects improves significantly.

Since around 1990, the use of groundwater by pumping up water from open dug wells set up in the command area has rapidly become popular under farmers' own initiative in some major irrigation schemes in the northwestern part of the dry zone. With higher rice yield made possible by better water control resulting from the conjunctive use of surface water and groundwater, the RCR in 1995 for the case that includes the cost of dug wells and pumps in addition to the O&M cost is estimated to be 0.88. Compared to the RCR of 0.97 for the case without the dug wells and pumps, the comparative advantage has improved considerably.[14]

What about factors that have brought about changes in the comparative advantage in rice production? The net social profitability (NSP) of rice production in the major irrigation regime including only the O&M cost is presented in Table 5 and the sources of changes in the NSP are shown in Table 6. Corresponding to the levels of RCR, the NSP is negative in 1968 and positive for all other years. The NSP was largest in 1980 and has followed a declining trend since then. The increase in NSP was thus substantial from 1968 to 1980.

The factor contributing the most to this improvement in comparative advantage was the depreciation of the exchange rate, followed by the increase in world rice price brought about by the food crises in the 1970s. The effect of a significant increase in productivity because of the diffusion of Green Revolution technology from 1968 to 1980 was reflected in the reductions in the input coefficients of domestic resources. The contribution of the reduction in land coefficient was particularly large, though the increase in land rent brought about by the increase in land productivity caused by the technological advance worked in the opposite direction. In Table 5, this effect of technological change is observed in the fact that the share of domestic resources in a unit of rice decreased considerably from 93% to 47% from 1968 to 1980.

From 1980 to 1985, the NSP in the major irrigation regime showed a large decline, mainly because of the decline in rice price in the world market as a result of the

[14]Farmers use water pumped up from tubewells much more for high-value nonrice crops than for rice. For more details on the diffusion of tubewells and pumps in Sri Lanka, see Kikuchi et al (2001b).

Table 5. Net social profitability (NSP) of rice production, major irrigation regime, Sri Lanka, 1968-95.[a]

	1968		1980		1985		1990		1995	
	(Rs t^{-1})	(%)	(Rs t^{-1})	(%)	(Rs t^{-1})	(%)	(Rs t^{-1})	(%)	(Rs t^{-1})	(%)
Rice price[b] (1)	611	100	4,302	100	4,173	100	6,657	100	9,082	100
Tradable inputs										
Fertilizer	38	6	524	12	472	11	923	14	1,038	11
Capital[c]	45	7	98	2	158	4	322	5	570	6
Others[d]	36	6	181	4	234	6	410	6	655	7
Total (2)	118	19	804	19	863	21	1,656	25	2,263	25
Domestic factors										
Labor	200	33	702	16	1,138	27	1,991	30	3,151	35
Land	263	43	961	22	1,050	25	1,774	27	1,813	20
Others[e]	105	17	376	9	614	15	1,091	16	1,627	18
Total (3)	568	93	2,039	47	2,802	67	4,856	73	6,590	73
Total (4) = (2) + (3)	686	112	2,843	66	3,665	88	6,512	98	8,853	97
NSP (1) – (4)	–76	–12	1,460	34	508	12	145	2	228	3

[a]Computed from Table 3. Five-year averages centering on the years shown. [b]Farm-gate equivalent border price of rice (in terms of paddy) converted to rupees by shadow exchange rate. [c]Two-wheel and 4-wheel tractors. [d]Seeds, agrochemicals, and fuel. [e]Buffalo, capital interest, irrigation (operation and maintenance), and domestic resource components in the marketing process of tradable inputs.

Table 6. Sources of change in net social profitability (NSP) of rice production (Rs t^{-1}), major irrigation regime, Sri Lanka, 1968-95.[a]

Variables	1968-80	1980-85	1985-90	1990-95
Change in NSP	1,535	–952	–363	83
Social value added				
Exchange value added	1,787	1,355	1,290	1,816
Rice price	1,488	–1,811	810	6
Input prices[b]	–290	248	–341	50
Input coefficients				
Biochemical inputs[c]	–38	28	8	–19
Mechanical inputs[d]	60	–8	–75	–35
Total	22	20	–67	–55
Total	3,006	–189	1,691	1,818
Social costs (deduct)				
Labor coefficient	–113	–171	–131	–552
Wage rate	616	606	984	1,712
Land coefficient	–434	–75	–66	–89
Land rent	1,132	164	790	128
Others[e]	271	239	476	536
Total	1,471	763	2,054	1,735

[a]Based on five-year averages shown in Table 5. [b]All tradable inputs combined. [c]Seeds, fertilizers, and chemicals. [d]Two-wheel tractor, 4-wheel tractor, and fuel. [e]Same as footnote *e* of Table 5.

success of the Green Revolution and irrigation development in the preceding decades in many developing countries in Asia including Sri Lanka. The absolute level of NSP as well as its change has become negligible since the mid-1980s; the continued depreciation of the exchange rate contributed to the amelioration of the comparative advantage, while increases in social costs counterbalanced this movement.

The stagnation of yield-increasing rice technology since the mid-1980s has been evident in the negligible changes in land coefficient. Instead, the reduction in labor coefficient because of the adoption of labor-saving technology has become increasingly important. Most noteworthy in recent years is the fact that the increase in wage rate has become a major factor that reduces the comparative advantage of rice production. In fact, the gain from the reduction in exchange rate was nearly canceled out by the increase in wage rate in 1995. A slightly faster growth in the wage rate, a slower improvement in labor productivity, and/or a reduced pace in the depreciation in exchange rate will easily turn the balance against rice production in the major irrigation regime.[15]

To have some hunches about future prospects in the comparative advantage, the RCRs under the major irrigation regime, estimated for different levels of critical variables while assuming that all other variables except for the one under question remain at the 1995 levels, are shown in Table 7. *Ceteris paribus*, a 50% increase in the wage rate over the 1995 level would bring the RCR up to a level far more than unity even for the case including the O&M cost alone. An improvement in labor productivity by one-third gives an effect in the opposite direction of nearly the same magnitude.

The degree of effect on the comparative advantage given by the world price of rice is much higher than that of the wage rate and the labor coefficient. A 50% rise in the world price lowers the RCR from 0.97 to 0.58 for the O&M-alone case. If the world price of rice rises to the level that prevailed during the food crisis of 1973-81, three times higher than the level prevailing in the mid-1990s, the RCR for the case including the cost of constructing new irrigation schemes improves to 1.11, which was the level Sri Lanka experienced once around 1980, the heyday of the Green Revolution (Table 4). Such results may be taken as indicating that, should the rice price soar up in the world market in the long run, as many food-crisis advocates insist, the domestic rice supply would increase through increases in irrigation investments in rehabilitation/modernization of existing irrigation infrastructure or even in constructing new infrastructure, whose investments are endorsed by their high net social profitability.

[15]Tables 5 and 6 present the results only for the major irrigation regime. The level and changing pattern of the NSP of rice production in the rainfed regime are surprisingly similar to those in the major irrigation regime in spite of the significant difference in productivity. In the 1980s and '90s, factors bringing about changes in NSP were fairly common between the rainfed and major irrigation regimes. Reflecting a higher input coefficient of tradable inputs, most importantly of fertilizer, than for rice production in the major irrigation regime, changes in their shadow prices in foreign currency had larger effects on the NSP in the rainfed regime. The effects of increases in wage rate and in labor productivity were even more pronounced in the rainfed regime.

Table 7. Resource cost ratio (RCR) of rice production under the major irrigation regime in 1995 for different levels of the international price of rice, the wage rate, and the labor coefficient.[a]

Price scenarios	O&M[b] alone	New construction	Rehabilitation	
			Minor	Major
RCR in 1995	0.97	4.99	1.00	1.08
Changes in				
International price of rice				
50% higher	0.58	2.67	0.60	0.68
100% higher	0.41	1.82	0.40	0.43
200% higher	0.29	1.11	0.27	0.31
30% lower	1.61	1.04	1.67	1.96
Wage rate				
50% higher	1.20	5.30	1.24	1.40
100% higher	1.44	5.61	1.47	1.64
Labor coefficient				
33% less	0.81	4.79	0.99	0.84
50% less	0.73	4.68	0.91	0.76

[a]The RCR is estimated for the assumed change in the variable, while assuming that all other variables remain at the 1995 levels. [b]O&M = operation and maintenance.

Actually, the world price of rice has been stagnating at the historic low level, or even declining, without showing any sign of rebound (Fig. 4). If this declining trend continues, the comparative advantage of rice production will certainly be lost. The world price of rice in 1999, which was more than 30% lower than the 1993-97 average, makes the RCR for the O&M-alone case as high as 1.6.

Indeed, should a food crisis arrive tomorrow, it would occur because of the low rice prices in the world market today. Figure 6 shows the trends in irrigation investments in Sri Lanka for the past half century. When comparing Figures 4 and 6, it is apparent that public irrigation investments have been driven by the level of the world price of rice. The total public investment in irrigation, including new construction, rehabilitation, and O&M, increased to an unprecedented high peak toward the mid-1980s. This jump in investment was induced by the jumps in the rice price in the world market in the 1970s because of the two food crises. Following the dramatic decline in the rice price since the late 1970s, the total public irrigation investment shrank dramatically from the mid-1980s to the mid-1990s.

It should be obvious from the extremely high RCR (i.e., the extremely low NSP) of rice production for the case including the cost of new irrigation construction that the government has had no incentive to invest in constructing new irrigation infrastructure under the circumstances prevailing since the mid-1980s (Table 3). It is therefore understandable that the new construction investment has shrunk drastically to a nearly negligible level. The fact that the investment in rehabilitating the existing irri-

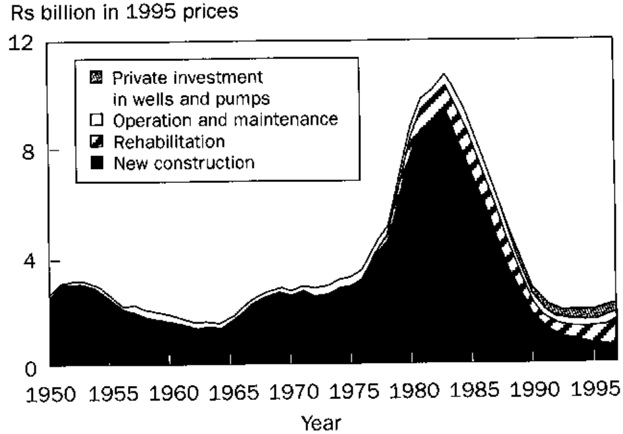

Fig. 6. Irrigation investments in Sri Lanka, 5-year moving averages, in 1995 constant prices, 1950-97.

gation infrastructure also decreased substantially from the mid-1980s to the early 1990s is less easy to explain, because the RCR for the case including the cost of rehabilitation did not become an overt disadvantage in the 1990s. In fact, Kikuchi et al (2001a) give rough estimates of the degree of underinvestment in irrigation rehabilitation as high as 50–60% in the early 1990s. The rehabilitation investment has shown an upward trend since the mid-1990s, but it was still underinvested by about 30% in 1997. Such estimates seem to suggest that the government and international donor agencies have overreacted to the low rice price, resulting in less-than-optimum rehabilitation investment.

Even more serious is the underspending on the O&M of the existing irrigation schemes. Since around 1970, the total O&M expenditure has been stagnant, or even decreasing, in spite of the positive NSP with O&M cost. Since a large tract of newly irrigated area was brought in by the investments made during the large investment peak in the 1980s, the actual O&M expenditure per ha of irrigated area has been declining rapidly, resulting in underspending as high as 60–70% in recent years (Kikuchi et al 2001a). Such a high degree of underspending on the O&M of the existing irrigation schemes continuing for a long time certainly results in a gradual quality deterioration of the schemes. This would in turn result in a deterioration of the comparative advantage of rice production through worsening input coefficients. Vulnerability thus accumulated gradually in irrigation schemes would eventually deprive the rice sector of resiliency in responding to the rise in the market price of rice. With such a situation prevailing not only in Sri Lanka but also in many other countries in monsoon Asia, a sudden rise in the rice price because of a demand-supply mismatch in a localized market could trigger a global food crisis.

Summary and implications

With few exceptions, insular or peninsular countries in the monsoon tropics in Asia used to be traditional rice importers. They were mostly exporters of estate crops, while importing rice. Many of these countries have actively pursued self-sufficiency in rice since the time of their independence in the late 1940s. Sri Lanka, among them, has attained the most outstanding success in this respect. Massive public investments in constructing irrigation infrastructure since the early 1950s and the diffusion of the Green Revolution technology since the late 1960s have been the major driving forces in achieving this success. This paper examined the level and trend in the comparative advantage of rice production in this development process with special reference to different types of irrigation investments. The major findings are summarized as follows:

1. Our estimation of the DRC indicates that, throughout the course of this development, rice production in the major irrigation regime has had no comparative advantage if the cost of new irrigation construction is taken into account. Drastic increases in productivity because of technological advances in the 1970s, together with the rise in rice price in the international market during the same decade, improved the social profitability of rice production considerably and might have given it a comparative advantage around 1980. However, the rapid cost escalation in new irrigation construction in the 1980s and thereafter that resulted from the shift of construction sites from easier to more difficult ones has made new irrigation construction out of the question from the comparative advantage point of view.
2. Even if we treat the cost of new irrigation construction as a sunk cost, taking into account only recurrent costs of operating and maintaining the existing irrigation schemes, rice production in the major irrigation regime had no comparative advantage prior to the diffusion of the Green Revolution technology. It is suggested that rice production in the rainfed regime also had no comparative advantage in those days. Within one decade after the introduction of the new seed-fertilizer technology, rice production in both regimes turned out to be highly socially advantageous relative to rice imports. Together with the possibility that rice production in the major irrigation regime even with the cost of new irrigation construction gained a comparative advantage during this period, our study demonstrates the profound effects that the Green Revolution technology had on rice production in Sri Lanka.
3. Given the irrigation infrastructure, the comparative advantage in rice production in the major irrigation regime has eroded since the time the country attained near self-sufficiency in rice in the mid-1980s. The same pattern has been followed by rice production in the rainfed regime. At present, rice production in Sri Lanka is nearly at par with the international rice market; it has lost the comparative advantage once enjoyed in the 1980s but it has not fallen into an overt comparative disadvantage either. This is so for rice production in the major irrigation regime even if the cost of minor rehabilitation projects is taken into

account. Even with major rehabilitation projects, the domestic resource cost ratio is not far above the breakeven level as long as the projects are implemented under reasonable conditions. The possibility of the conjunctive use of surface water and groundwater in major schemes by means of tubewells and pumps improves the comparative advantage considerably.

4. The major factor that has been pushing down the comparative advantage of rice production is the increase in the agricultural wage rate. As the nonrice sector, particularly the nonfarm sector, continues to develop, resulting in continuous increases in the real wage rate, the rice sector in Sri Lanka will lose its comparative advantage completely and certainly face, sooner or later, a worsening comparative disadvantage. Sri Lanka is thus returning to its traditional position of comparative disadvantage in rice production.
5. The world-rice-price elasticity of the comparative advantage is higher than the wage-rate elasticity, that is, a percentage change in the comparative advantage brought about by a percentage change in the international price of rice is larger than a percentage change in the comparative advantage brought about by a percentage change in the wage rate. Actual changes in the comparative advantage of rice production brought about by changes in the world rice price have been small in the 1990s, for the rice price has been stagnant at, or declining slightly from, the unprecedented low level that the international rice market experienced after the collapse of the commodity boom in the mid-1980s.

Of the findings above, the most important should be that Sri Lanka is losing its comparative advantage in rice production mainly because of the rise in the wage rate. This has been the case in many land-scarce Asian countries, typically in East Asia, but followed recently by many developing countries in rice-growing tropical Asia (Estudillo et al 1999). It is possible to counteract this declining trend in comparative advantage by increasing the productivity of rice production through some technological breakthrough, such as the Green Revolution three decades ago.[16] In the case of Sri Lanka, however, a large increase in domestic rice production resulting from such a technological breakthrough will almost immediately reach the consumption ceiling, forcing the country to face a serious rice surplus problem.

Under the condition that it is difficult for Sri Lankan rice to find a market in world rice trade because of its specific quality, the only option for maintaining domestic rice production that is economically sound is to increase labor productivity by pursuing economies of scale, which require significant increases in farm size. This necessitates the smooth transfer of domestic resources in the rice sector, labor in particular, to the rapidly developing nonfarm sector. This is a typical problem the peasant rice sector not only in Sri Lanka but in many other countries in Asia has to resolve in the adjustment phase of its agricultural development (Hayami 1988, Johnson 1991). The most important implication of this study is that the rice sector in Sri Lanka has already entered in this difficult stage of economic development.

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[16] This is a prescription given by Estudillo et al (1999) for the Philippines.

The most critical necessary condition for this structural adjustment in the rice sector to be successful is the existence of well-working labor and land markets, among others. The labor market in Sri Lanka works rather well (World Bank 1996), but the land market does not (Bloch 1995, Kikuchi 2000). The virtual nonexistence of the land market and persistent supra-economic values given to rice production in Sri Lanka would constrain the structural adjustment of the rice sector seriously. There will be a temptation for the government of developing countries like Sri Lanka to resort to the argument of multifunctional values of agriculture, now advanced primarily by industrialized countries in East Asia and the European Union in the face of the trade negotiations of the World Trade Organization, which may further blur the real need of this structural adjustment.

Rice policies in Sri Lanka have long been characterized by strong paternalism: the government is supposed to embrace and take care of all the rice farmers. Such a stance of the government is of course not suited at all in the adjustment phase. A clear change in the government stance toward rice production policies is most clearly observed in an interministerial policy proposal, in which it is discussed to apply rice production policies selectively to different groups of rice farmers with a view to strengthening the comparative advantage of rice production while avoiding overproduction (Ministry of Agriculture et al 2000). This makes it clear that the government is aware of the need to promote structural policies in the rice sector. But, how far the government succeeds in adopting necessary policies to promote, or in not adopting policies that are against, structural changes in the adjustment phase under the strong political pressure emanating from vested interest groups and agricultural fundamentalism is a different story.

Another interesting finding in this paper is that the rice-price elasticity of the comparative advantage of rice production is higher than the wage elasticity. This implies that the domestic rice supply would increase resiliently as the rice price rises in the international market. It is suggested, however, that the dynamic process of rice supply involving adjustments in irrigation infrastructure could not be perfectly reversible. The serious underinvestment in irrigation infrastructure, most notably in the O&M of the existing irrigation systems, resulted from the long-lasting low price regime in the international rice market, which might deprive the irrigation sector of this resiliency and be preparing conditions for future food crises. Adequate maintenance and appropriate rehabilitation of the existing irrigation infrastructure are a prerequisite for preventing the comparative advantage of rice production from falling into a disadvantage.

This paper also showed a possibility of improving the comparative advantage of rice production through the conjunctive use of surface water and groundwater. Indeed, the diffusion of tubewells and irrigation pumps has been quite rapid in Sri Lanka because of the high rate of return to well and pump investments by farmers (Kikuchi et al 2001b).[17] Since this diffusion began in Sri Lanka relatively recently, about a

[17]As shown in Figure 6, the total private investments in tubewells and pumps far exceed the O&M expenditures at present.

decade ago, compared with other countries such as India, the overexploitation of groundwater has so far not become an overt problem. It is feared, however, that, if the rapid diffusion of tubewells and pumps continues, the groundwater resources in the country might be hurt irreversibly (Panabokke 1998). Together with increases in the urban and industrial demands for water, whether water becomes a constraint in the resiliency of the rice supply system in the long run must be studied carefully.

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Notes

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