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Sustainable Agriculture, Poverty and Food Security

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AM 0334731 Code I-E-2002286787 Vol 1

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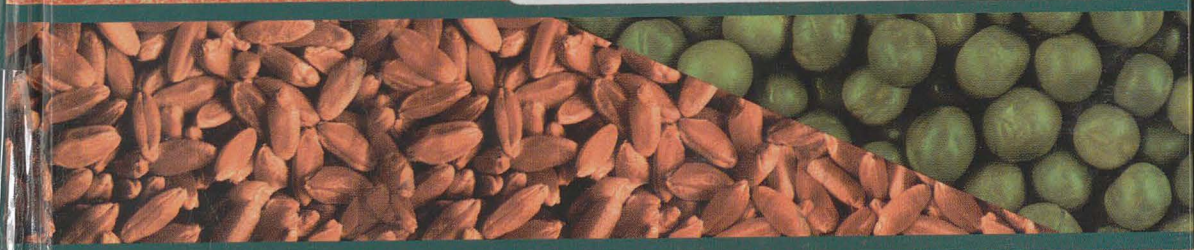

Volume 1

Sustainable Agriculture, Poverty and Food Security

Agenda for Asian Economies

VOLUME 1

Edited by

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RAWAT PUBLICATIONS
Jaipur and New Delhi

ISBN 81-7033-725-9 (set)
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Published by
Prem Rawat for ***Rawat Publications***
Satyam Apts., Sector 3, Jain Temple Road, Jawahar Nagar, Jaipur - 4 (India)
Phone: 0141 651748 / 657006 Fax: 0141 651748
e-mail : info@rawatbooks.com
www.rawatbooks.com

Delhi Office
G-4, 4832/24, Ansari Road, Daryaganj, New Delhi 110 002
Phone: 011-3263290

Typeset by Rawat Computers, Jaipur
Printed at Chaman Enterprises, New Delhi

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Comparative Advantage of Rice Production in An Ex-Rice-Importing Country: The Case of Sri Lanka, 1968-97

M. Kikuchi, R. Barker, M. Samad and P. Weligamage

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 to attain rice self-sufficiency in traditional rice-importing countries in the region. Thanks to massive public investments on irrigation infrastructure since the 1950s and to the technological advances in rice farming, popularly heralded as the Green Revolution taken place in the two decades since the late 1960s, the major rice-importing countries in South and Southeast Asia have experienced rapid increases in rice production, and succeeded to attain, or nearly attain, this national target (Barker and Herdt, 1985; Pingali *et al.*, 1997).

In retrospect, many of these traditional rice-importing countries, mostly insular or peninsular countries, used to be specialised in the production of such estate crops as sugarcane, tea, coconut, and fiber crops. It should be reasonable to consider that such specialisation was established through the advantage these countries had in the production of these estate crops in contrast to traditional rice-exporting countries situated in large river deltas (Wickizer and Bennett, 1941).

If so, was the policy target of rice self-sufficiency pursued by the traditional rice-importing countries in the post-World War II period while without having a comparative advantage in rice production? Or, was it the case that the irrigation development and the diffusion of the Green Revolution technology had even traditional rice-importing countries gain a comparative advantage in rice production? An even more important policy question in the face of the on-going WTO negotiation is whether these countries still keep, or have ever been with, a comparative advantage in rice production. Information available on these issues is scanty, except a recent study by Estudillo *et al.* (1999) that finds that the Green Revolution turned a comparative disadvantage in rice production to a comparative advantage in the largest rice-bowl in the Philippines but the advantage was totally lost again towards the end of the 1980s.

In order to secure more evidence on these issues, we examine in this paper historical changes in the comparative advantage of rice production in Sri Lanka by estimating the domestic resource cost (DRC). There have been two studies, Edirisinghe (1991) and Shilpi (1995), that estimated the DRC. The results of these studies, both estimating the DRC for the early 1990s, are contrasting; the former indicates some comparative advantage for rice production in Sri Lanka, whereas the latter insists no comparative advantage at all. A common defect in these two studies is that they used data obtained at one time-point. This is particularly problematic in the DRC estimation of agricultural crops, such as rice in Sri Lanka, where rice yields a critical determinant of the DRC, fluctuates significantly year to year. One time-point estimate also makes it difficult to know the direction of change in a comparative advantage overtime. We try to overcome these defects by dealing with a long-term trend in rice production.

Conceptual Framework, Data and Assumptions

Comparative Advantage

Chenery (1961) defines that 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 the 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 measured by evaluating it by shadow prices. 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 export a unit of rice. On the other hand, the social opportunity cost of rice is the value of domestic resources and tradable inputs that are used for producing a unit of rice production, evaluated at their shadow prices. If the social benefit (i.e., international price) 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.

Classifying production inputs into two groups, viz., tradable inputs and non-tradable domestic resources, and expressing in equations,

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

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 i-th tradable input to produce rice,
P_i = shadow price of i-th tradable input in foreign currency,

b_j = input coefficient of j-th domestic resource to produce rice, and
P_j = shadow price of j-th domestic resource
Rice production has a comparative advantage, when

$B > C$, 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* (=DRC), NSP > 0, i.e., 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.[1]

Sources of Change in Comparative Advantage

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 change in NSP is decomposed into changes in the international price of rice, the input coefficients and the international prices of tradable inputs, the shadow exchange rate, and the input coefficients and their shadow prices of domestic resources. The sources of change in comparative advantage for a certain period can be assessed by inserting respective variables into equation (3).

Data and Assumptions

Cost of Rice Production[2]

Necessary data to identify overtime changes in the input coefficients (a_i and b_j) in rice production are obtained from the Cost of Cultivation of Agricultural Crops (CCAC), compiled by the Department of Agriculture from the 1978/79 to present. Since this series reports the cost of rice production by irrigation regime, the 'major irrigation' regime and the 'rainfed' regime, the DRC estimation is made for these two regimes separately.[3] Selecting four districts for the major irrigation regime and two districts for the rainfed 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 weight. The selection of the sample districts is based on their representativeness and the availability of data continuously from the inception of the survey to the latest one. 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 differ little between 'maha' (the northeast monsoon) season and 'yala' (the southwest monsoon) season, the average of the two seasons is used in the analysis.

Unfortunately, in 1980, the Green Revolution technology was already at the last stage of its diffusion. In order to extend our data series to the years before the introduction of the new rice technology, we try to use the data on rice production cost collected by Jogaratnam *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 schemes[5] 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 percent broken (Edwards, 1993; Shilpi, 1995), so we take the Colombo CIF equivalent of the FOB price at Bangkok of Thai 25 percent broken as the border price of rice (P_w). The shadow prices of tradable inputs (P_i) are estimated by applying 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 adjusting for freight and insurance.[6] The same tariff/subsidy coefficient is assumed for other fertilisers. 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 data used by Shilpi (1995).

The domestic (non-tradable) resources used in rice production are labour, buffalo, land and the interests borne to fund sunk in the production process. For labour 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.[7] No price data are available for land and capital interests in the cost of 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 as explained in the next section. 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 non-land costs from the output value. The residual is supposed to consist of the returns to land and farmer's management, and profit. The residual represents the upper-bound of returns to land, as long as the non-land costs are valued properly and the profit is close to zero as supposed to be so in the long-run equilibrium. Following Shilpi (1995), the interest rate in rural areas is assumed to be 30 percent per year.

Shadow Exchange Rate

Shadow exchange rate (SER) is another hazardous variable to determine. Bhalla (1995) estimates that the official exchange rate (OER) was overvalued by 15 percent

for the period 1966-1970. For the 1980s and the 1990s, Shilpi (1995) estimates that the OER was overvalued by 16 percent in the early 1980s and by 10 percent in the early 1990s.[8] Based on these studies, let us assume 16 percent of overvaluation for 1968, 1980 and 1985, and 10 percent for 1990 and 1995.[9]

Irrigation Costs[10]

As will be shown in the next section, irrigation has been the most critical factor in Sri Lanka that determines the productivity of rice production. 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. 1,556 per hectare in 1993 prices, the level the Irrigation Department sets as the 'desired level' of O&M expenditure per hectare for the major irrigation systems. It is assumed that this level of O&M activities can all 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.[11] 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 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 analysed in Aluwihare and Kikuchi (1991).

For all these investment costs, the capital cost is annualised by applying the interest rate of 10 percent that is widely applied in this kind of studies. 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 non-traded goods. The percentage share of traded goods in the total costs is assumed to be 7 percent for the new construction project and 27 percent 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 percent for the new construction and 20 percent for the major rehabilitation project.

Development of Rice Production in Sri Lanka

Before proceeding to the results of DRC estimation, let us review the development of the rice sector since independence and changes in rice farming for the period 1968-1995.

The Development of the Rice Sector

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). Just after independence in 1948, the country produced only 36 percent of the total rice requirement. In the mid-1990s, the rate of self-sufficiency was more than 90 percent, and rice was even exported in some years. Sri Lanka has been enjoying virtual self-sufficiency in rice for the last two decades. In fact, with a declining trend in percapita rice consumption in recent years[12], Sri Lanka faces the danger of over-production of rice.[13] As far as the national policy target of attaining rice self-sufficiency is concerned, no one can deny that Sri Lanka has achieved a remarkable success.

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

	Paddy Yield per ha	*Paddy harvested area*	*Paddy prod.*	*Rice import*	*Rice export*	*Rice self-sufficiency rate*	*Per capita rice consumption*	*MV ratio*	*Nitrogen per ha*
	(1)[b]	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*[c]	*(7)*[d]	*(8)*[e]	*(9)*
	mt	*1000 ha*		*... 1000 mt ...*		*%*	*kg*	*%*	*kg*
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	1409	523	0	73	104	68	45
1980	2.56	807	2065	271	3	89	107	87	82
1990	3.11	760	2362	306	0	89	105	92	116
1995	3.12	791	2473	244	23	92	100	96	136
Growth rate (%/year):									
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	2.0	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

Notes: 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.

Source: See Aluwihare and Kikuchi (1991) except for (5) and (12). The data on rice export are from FAOSTAT, and the data on the GDP deflator are from CBSL (1998).

Increases in rice production had been particularly rapid until 1980 (Table 1). Though still increasing, g ɔwth in rice production has decelerated apparently since then. This deceleration coincided to a large extent with the exhaustion of the yield potential of the Green Revolution technology. Unlike other countries in Asian

tropic where the Green Revolution in rice began in the late 1960s with the release of IR8 (the first modern varieties; MVs) from the International Rice Research Institute in the Philippines, the seed-fertiliser 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 diffuse in the late 1950s, and another series of improved varieties (BG series; called new improved varieties), also locally developed, followed the old improved varieties after a decade.[14] The diffusion of this Sri Lankan version of MVs and the corresponding increase in fertiliser intensity brought about rapid improvements in rice yield per hectare (Table 1).

Table 2 *Area planted to rice and rice production by irrigation regime, Sri Lanka, 1950-1997*[*]

	Area planted to rice				*Rice production*			
	Major	*Minor*	*Rainfed*	*Total*	*Major*	*Minor*	*Rainfed*	*Total*
		... 1000 ha ...				*... million mt ...*		
1950	111	94	237	441	na	na	na	na
	25	*21*	*54*	*100*				
1960	173	156	253	582	na	na	na	na
	30	*27*	*43*	*100*				
1970	245	185	292	722	na	na	na	na
	34	*26*	*40*	*100*				
1980	324	201	335	860	0.98	0.43	0.66	2.06
	38	*23*	*39*	*100*	*48*	*21*	*32*	*100*
1990	389	171	254	814	1.36	0.40	0.60	2.36
	48	*21*	*31*	*100*	*58*	*17*	*25*	*100*
1995	422	176	233	832	1.45	0.48	0.54	2.47
	51	*21*	*28*	*100*	*59*	*19*	*22*	*100*
Growth rate (%/year)								
1950-60	4.6	5.2	0.7	2.8	-	-	-	-
1960-70	3.5	1.8	1.4	2.2	-		-	-
1970-80	2.9	0.8	1.4	1.8	-	-	-	-
1980-90	1.8	-1.6	-2.7	-0.5	3.3	-0.7	-0.9	1.4
1990-95	1.6	0.5	-1.7	0.4	1.3	3.7	-2.1	0.9

* Five-year averages centering on the years shown, except for 1950 that is 1950-53 average. Figures in italic are percentages.

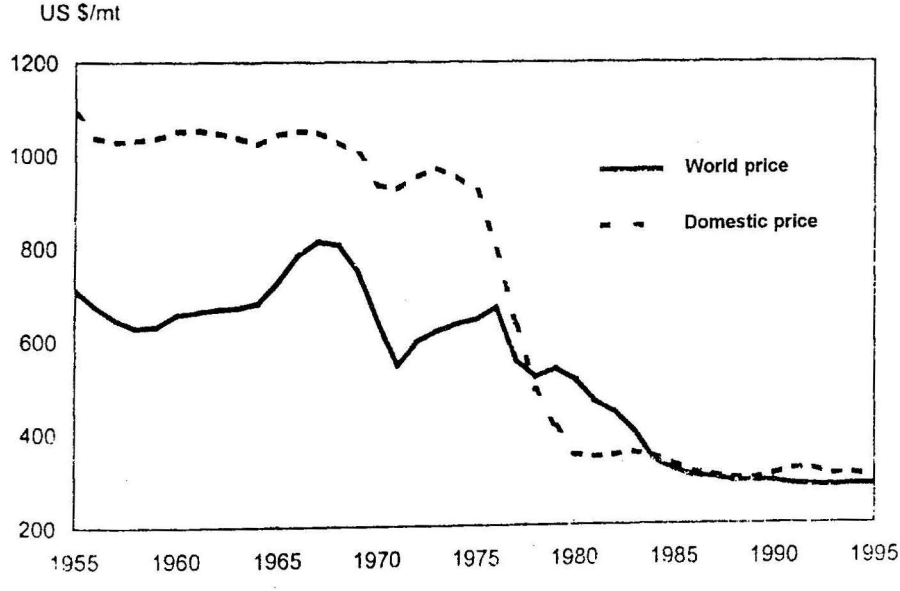
Source: See Aluwihare and Kikuchi (1991).

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). Sri Lanka is divided into two different climatic zones: the wet zone and the dry zone. Rice production in the dry zone that consists of more than two-thirds of the country in terms of area requires irrigation water not only in the

second season but even in the main season. In pursuit of rice self-sufficiency, massive investments had been made towards 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 construct new irrigation systems in the dry zone.[15] As shown in Table 2 above, the share of irrigated area in the total area planted to rice increased from about 45 percent in the early 1950s to more than 70 percent in the mid-1990s. Particularly distinct was the significant increase in rice planted area irrigated by major irrigation schemes (schemes with the command area of more than 80 hectares). 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 percent produces nearly 80 percent of total rice output in the country.

An inevitable consequence of the success in increasing domestic rice production is dramatic declines in rice price (Figure 1). In the international rice market, as the Green Revolution technology was adopted successfully in the developing countries in Asia from the late 1960s to the mid-1980s, the rice price deflated by the world export price index, peaked in the late 1960s in terms of five-year moving averages, declined by the mid-1980s to a level nearly one-third of the peak level and has stayed at that level since then. The domestic rice price in Sri Lanka followed the international price, but the degree of decline from the mid-1970s to the early 1980s was higher than that of the world price. This is because it involved the narrowing of large positive gap between the domestic and international prices. Since the mid-1980s, the real rice price in the domestic market as well as in the world market has stayed nearly stagnant at the low level that was reached after the collapse of the

Figure 1 *World rice price (Thai 25% broken; Colombo CIF) and domestic rice price (farm-gate price of rough rice in milled rice equivalent at Colombo port), 1958-97, deflated by the world export price index (1995=100), five-year moving averages*



commodity boom in the early 1980s. It is thus consumers that have received the benefits of the productivity increase in rice production in the form of consumer surplus, in addition to the income transfer resulted from the reduction in the rate of protection for rice farmers.

Changes in Rice Farming

Changes in input intensities in rice production are presented in Table 3, together with land, labour and total factor productivities, by irrigation regime for the years

Table 3 *Rice yield, input intensities in rice production per ha of planted area and productivities, Sri Lanka, 1968-1995, by irrigation regime, averages of maha and yala seasons*[a]

	Rice	*Input intensities*								*Labour productivity*	*Total factor productivity*
		Current inputs				*Capital*[e]			*Labour*		
	yield	*Seed*	*Fertilizer*[b]	*Chemical*[c]	*Fuel*[d]	*Buffalo*	*2 wheel tractor*	*4 wheel tractor*			
	mt	*kg*	*kg*	*liter*	*gallon*	*hr*	*hr*	*hr*	*day*	*kg/day*	*index*
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
Growth rate (%/year)											
Major irrigation											
1968-80	5.4	0.6	6.8	26.4	-3.2	4.0	-	-1.0	2.9	2.4	4.2
1980-85	1.5	0.8	0.3	-0.2	-3.9	-11.2	37.0	-4.2	-2.1	3.7	2.0
1985-90	0.9	0.1	0.2	2.3	9.1	-13.2	12.7	2.4	-0.7	1.7	0.6
1990-95	1.0	1.9	1.8	0.7	4.8	-46.4	3.2	0.9	-3.1	4.3	1.6
Rainfed											
1980-85	0.6	0.4	-5.1	-6.8	11.9	-10.3	20.3	14.1	0.1	0.5	0.5
1985-90	-1.0	1.1	-1.1	6.6	15.8	2.7	7.9	16.4	-2.1	1.2	-1.5
1990-95	1.8	1.8	2.9	4.0	6.3	-18.8	7.5	2.4	-1.4	3.3	2.1

Notes: a Based on five-year average centering on the years shown except for 1968. Estimated from the Cost of Cultivation of Agricultural Crops except for 1968. For 1968, from Jogaratnam (ud).
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 in 4 wheel tractor.

for which the cost of production data are available. For the major irrigation regime, major changes in rice production structure occurred between 1968 and 1980. The intensities of fertiliser and chemical inputs increased significantly. It should be reminded that between these years major rice varieties planted by farmers changed from traditional and old improved varieties to new improved varieties. The increases in fertiliser and chemical intensities reflect the fertiliser-chemical using nature of the new improved varieties. Labour inputs per hectare of planted area also increased about 40 percent between these two years, suggesting the labour absorbing nature of the seed-fertiliser technology. The impact of this technological change in rice farming on productivity was also substantial. Rice yield per hectare (land productivity) increased by nearly two times and labour productivity was improved in spite of the increase in labour intensity. Altogether, the total factor productivity increased by more than 60 percent in this period.

The deceleration in land productivity growth for the major irrigation regime in the 1980s and 1990s is apparent. Fertiliser intensity continued to increase but only marginally and so was rice yield per hectare. All this suggests that the yield potential of the seed-fertiliser technology had mostly been exhausted by the early 1980s. On the other hand, some non-yield-increasing technical changes went on. Most notably, the land preparation by draft power was rapidly substituted for by two-wheel tractor, which accompanied the substitution of capital services for labour. The quantity of seed paddy per hectare showed a slightly increasing trend, reflecting the gradual shift of the method of crop establishment from transplanting to direct seeding. Since direct seeding requires less labour inputs, this technical change also contributed to reducing labour intensity. Underling the adoption of these labour saving techniques was the rise in agricultural wage rate relative to rice price and capital rental rates during the 1980s and 1990s. As a result, labour productivity grew much faster than land productivity, while the rates of improvements in total factor productivity were in-between.

For the rainfed regime for which data are available only for 1980 (1978-82) and thereafter, there was no significant change in rice yield per hectare. Indeed, fertiliser intensity was highest in 1980 when the fertiliser-rice relative price was lowest because of heavy fertiliser subsidies around that year (see Table 5 shown later). As in the major irrigation regime, the substitution of capital services for labour through tractorisation and the labour saving due to the gradual diffusion of direct seeding progressed. As a result, labour productivity was 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.

The changes in the cost structure of rice farming are encapsulated in the changes in factor shares (Table 4). These are the shares of nominal input costs at current value of rice output per ha, valuing all the non-land inputs, including such self-supplied inputs as family labour inputs, by respective market prices. As mentioned earlier, the residual after subtracting all the non-land input costs from output value is expected to measure the returns to land. For the major irrigation regime, the shares of current

inputs, labour and capital all increased in the 1980s and the 1990s, significantly for current inputs and labour and marginally for capital, while the share of land (residual) decreased significantly in the last two decades. Paralleled by the increases in the input intensity, the increases in their factor shares may represent the fertiliser-using and capital-using nature of the technical changes. In the case of labour, the increase in factor share was brought about by the increase in the wage rate, which was faster than the rate of decrease in labour intensity in the process of capital-labour substitution.

Table 4 *Factor shares in rice production per ha by irrigation regime, average of maha and yala seasons, Sri lanka, 1968-1995*

	Factor shares in output				
	Total	*Current inputs*	*Capital*	*Labour*	*Residual*
Major irrigation					
1968	100	14	13	32	41
1980	100	17	12	30	41
1985	100	20	13	35	32
1990	100	22	13	35	30
1995	100	25	14	39	22
Rainfed					
1980	100	20	7	36	37
1985	100	18	9	42	31
1990	100	23	13	46	18
1995	100	29	13	58	0

Note: Five-year averages centering on the years shown, except for 1968 of major irrigation schemes. Estimated from DA's Cost of Cultivation of Agricultural Crops, except for the 1968 shares, which are estimated based on Jogaratnam (ud).

Similar trends are observed for the rainfed regime. An increasing trend for current input after 1985 was brought about by the increases in input intensities of all groups of current inputs (Table 3), which corresponded to such technical changes as tractorisation (increase in fuel consumption), the diffusion of direct seeding, and, at a lesser extent, to the diffusion of seed-fertiliser technology. The increasing trends of capital and labour shares are clearer in the rainfed regime than in the major irrigation regime. Particularly, the share of labour has reached in 1995 a level as high as 58 percent. In contrast, the share of land has dropped drastically from 37 percent in 1980 to 0 percent in 1995 with the rate of decline particularly high in the 1990s. In our framework, the land share of 0 percent means no return to land in rice production, which is of course hardly conceivable.

A possible source of such an anomaly is failures in imputing self-supplied inputs used in rice production, family labour inputs in particular. Assuming the well-functioning rural labour market, family labour inputs are imputed in this paper by the market wage rates for respective farm tasks. The opportunity cost of family

labour could be lower than the market wage rates, if, for instance, the movement of the family labour force is restricted for some reasons. The malfunctioning land market in the wet zone, where the overwhelming majority of rainfed paddy fields are found, could be a good reason for such a restriction. It is said that the landownership in the small holder sector in the wet zone is awfully complicated; many claimants for a small piece of land, enormous number of land disputes hanging around in the courts for decades, extreme difficulty of re-seizing farm land once lent out or occupied by someone else for a certain period, etc. (Bloch, 1995; World Bank, 1996). Under such circumstances that make the land market virtually non-existent, the movements of family labour, particularly of the farm operator, would be restricted seriously, as long as he/she wants to retain his/her farmland.

It is hard to believe zero opportunity cost for family labour, but it is equally hard to believe that the market wage rates represent the opportunity cost under the conditions of the land market in the wet zone.[16] It is certain, however, that the true shadow price of family labour lies between these two polar cases. It is of critical importance for establishing effective rural/agricultural policies to examine in more details the impacts of the malfunctioning land market on the labour allocation in rural households. Since in this paper we measure the shadow value of land service by the residual after subtracting from the output value the total non-land input cost while imputing self-supplied inputs at their market prices, however, at which level between the two polar cases the shadow price of family labour is in reality does not alter the estimate of the DRC.

Lastly, in this section, let us observe the nominal protection/subsidy coefficient for rice and urea as proxies for the government policy stance towards the rice sector (Table 5). The nominal protection rate for rice, which had been as high as 50-70 percent until the mid-1970s, was reduced significantly towards 1980. As we have seen in Figure 1, the nominal protection rate for rice had been as high as 50-70 percent until the mid-1970s, suggesting a heavy bias towards protection in the government rice price policy. The nominal protection rate for rice sharply dropped, became even negative around 1980, and has stayed insignificant since the mid-1980s. On the other hand, the rate of subsidy for urea fertiliser, which had been about 20 percent in the late 1960s, drastically increased to a level as high as more than 70 percent.

Around 1980, the rice sector was at the final approach in attaining the self-sufficiency in rice and the government kept the traditional stance of boosting domestic rice production and protecting rice farmers through extending heavy subsidies for fertilisers 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 nominal protection coefficient for rice became about one and stayed at that level thereafter. The rate of fertiliser subsidy of more than 40 percent continued until 1991 when the government had to abolish it completely as a part of the conditionality for obtaining the World Bank/IMF loan. But, it was restored again in 1994, so that fertilisers were subsidised by about 15 percent on average for 1993-97.

Table 5 *Border and farm-gate prices of rice and urea in Sri Lanka, 1968-95, five-year averages centering on the years shown*

				1968	1980	1985	1990	1995
Rice price:								
(1)	Thai rice price, FOB Bangkok	US$/mt		162	344	216	257	257
(2)	Freight & insurance rate	US$/mt		3	19	17	13	12
(3)	Rice import price, CIF Colombo	US$/mt	(1)+(2)	164	363	232	270	269
(4)	Producer price of rice at farm-gate	Rs/mt		674	2593	3794	6493	8682
(5)	Producer price of rice at Colombo port	Rs/mt		1155	4444	6502	11128	14879
(6)	Official exchange rate	Rs/US$		5	18	27	39	53
(7)	Producer price of rice at Colombo port	US$/mt	(5)/(6)	210	253	243	288	283
(8)	Nominal protection coefficient		(7)/(3)	1.28	0.70	1.05	1.07	1.05
Urea price:								
(9)	World price of urea, FOB Europe	US$/mt		68	183	133	151	140
(10)	Urea import price, CIF Colombo	US$/mt	(9)*1.28	87	234	170	194	179
(11)	Domestic urea price at farm-gate	Rs/mt		492	1435	3163	5403	9739
(12)	Domestic urea price at Colombo port	Rs/mt	(11)/1.24	397	1157	2551	4358	7854
(13)	Domestic urea price at Colombo port	US$/mt	(12)/(6)	72	66	95	113	149
(14)	Implicit tarif/subsidy coefficient		(13)/(10)	0.83	0.28	0.56	0.58	0.84

Notes: (1) The price of 25% broken, from IRRI World Rice Statistics 1995. For 1993-97, estimated from the price of 5% broken.
(2) US$12/mt in 1988 (FAO 1988) adjusted for by the price index of world crude oil price (WTRG Economics, Home Page; http://www.wtrg.com/price.htm).
(4) Rough rice price; weighted averages of guaranteed price and market prices, using the quantity as weights.
(5) Assume 0.671 of conversion rate between rough rice (paddy) and milled rice and 15% of margin for collection, transport, milling and handling between farm-gate and Colombo port, based on Shilpi (1995).
(9) From IRRI (1995). For 1993-97, estimated from the Colombo CIF price of all fertilizers.
(10) Assume 28% of freight and insurance, based on Edirisinghe (1991) and Shilpi (1995).
(11) From DA's Cost of Cultivation of Agricultural Crops, the average of the sample districts.
(12) Assume 24% of margin for transport and handling, based on Shilpi (1995).

Changes in Comparative Advantage

The estimated domestic resource cost (DRC) and resource cost ratio (RCR) are presented in Table 6 by irrigation regime and by level of 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,[17] we treat this as the basic case for the major irrigation regime.

Assuming that the official exchange rate (OER) indeed represented the equilibrium exchange rate, it is estimated that the RCR for rice production in the major irrigation regime declined from 1.34 in 1968 to 0.68 in 1980. That is, rice production did not have a comparative advantage just before the adoption of the new

improved rice varieties and associated seed-fertiliser technology, but as the Green Revolution technology reached a high diffusion level, it turned out to have a comparative advantage.[18] Since 1980, however, the comparative advantage had been lost again by 1990 and the RCR has been at about the breakeven level in the 1990s.

Table 6 *Domestic resource cost (DRC), shadow exchange rate (SER) and resource cost ratio (RCR) of rice production by irrigation regime, Sri Lanka, 1968-95*[a]

	Domestic resource cost (DRC)	*Shadow exchange rate (SER)*			*Resource cost ratio (RCR)*		
		OER[b]	*OER*1.10*[c]	*OER*1.16*[d]			
	(1)	*(2)*	*(3)*	*(4)*	*(1)/(2)*	*(1)/(3)*	*(1)/(4)*
Major irrigation[e]:							
1968	7.4	5.5		6.4	1.34		1.15
1980	11.9	17.6		20.4	0.68		0.58
1985	26.2	26.7		31.0	0.98		0.85
1990	41.3	38.6	42.5		1.07	0.97	
1995	56.0	52.7	57.9		1.06	0.97	
Rainfed:							
1980	12.0	17.6		20.4	0.68		0.59
1985	30.7	26.7		31.0	1.15		0.99
1990	44.7	38.6	42.5		1.16	1.05	
1995	55.7	52.7	57.9		1.06	0.96	
All country[f]:							
1980	11.9	17.6		20.4	0.68		0.59
1985	28.1	26.7		31.0	1.05		0.91
1990	42.6	38.6	42.5		1.10	1.00	
1995	55.9	52.7	57.9		1.06	0.97	

Notes: a OER = official exchange rate.
b All related variables are in terms of five-year averages centering on the years shown, except for some variables explained in the text and other tables. Average of maha and yala seasons.
c Assume 10% over-valuation in the exchange rate in the 1990s, based on Shilpi (1995).
d Assume 16% over-valuation in the exchange rate in the 1980s and earlier, based on Shilpi (1995) and Bhalla (1991).
e The ideal level of O&M expenditure is included as cost.
f Aggregated using the rice production in each regime as weights, while assuming the average of the two regimes for the minor irrigation regime.

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 the two regimes while assuming the average of the two regimes for the minor irrigation regime, followed more or less the same pattern as the two regimes showed.

It is nearly certain that the OER has overvalued the real exchange rate. To the extent that the shadow exchange rate (SER) diverges from the OER due to overvaluation, the RCR becomes smaller. Our assumption that the rate of overvaluation of the OER was 10 percent in the 1990s and 16 percent in the 1980s and 1968 reduces the RCR levels slightly but does not change the trends much. For the major irrigation regime, the RCR was less than unity for all the years except 1968. For the rainfed regime and for the country as a whole, it was far less than unity in 1980, increased but still less than unity in 1985, increased to the breakeven level in 1990, and stayed nearly constant since then.

Our DRC estimates being subject to unknown degree of statistical errors, we have to be careful in drawing some conclusions from our 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 at present. It may be worth emphasising that rice production in the major irrigation regime that shares about 70 percent of 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 percent, the RCR in 1968 is estimated to be 1.15. It should be reminded that the reliability of data for 1968 is weaker than for the years in the 1980s and the 1990s. 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 towards unity, and for the rate of overvaluation larger than 34 percent 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 1960s, seem to be sufficient to give a support to our conjecture that in earlier years before the advent of the Green Revolution technology rice production in Sri Lanka used to be with a comparative disadvantage but such a situation was improved significantly towards 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 7 presents the results of 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 from 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.

Table 7 *RCR of rice production under the major irrigation regime by type of irrigation investment, Sri Lanka, 1968-95*[a]

Year	*O&M*[b] *alone*	*New construction*[c]	*Rehabilitation*[d]	
			Minor[e]	*Major*[f]
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

Notes: a Assume over-valuation in the exchange rate of 16%, 16% and 10% for 1968, the 1980s and the 1990s, respectively. Five-year average centering on the years shown.
b The ideal level of O&M expenditure (Rs 1828/ha/year in 1995 prices).
c The cost of constructing new irrigation systems in addition to O&M.
d The cost of rehabilitating irrigation system in addition to O&M.
e Water-management improvement with minor rehabilitation.
f Major rehabilitation project (represented by the unit cost of the ISMP).

As in other developing countries, however, the O&M of these irrigation schemes has rarely been adequate, resulting in rapid deterioration in the quality and performance after their construction. Irrigation rehabilitation aims at restoring the quality of deteriorated schemes to, or modernising them to a level higher than, the original design. Rehabilitation projects can be grouped into two depending on the emphasis of the projects: 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, the RCR estimates with the rehabilitation cost are shown in Table 7 for 1980 and thereafter.

The inclusion of 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 ever since three decades 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 since the time when the Accelerated Mahaweli Development Project commenced (Kikuchi *et al.*, forthcoming), 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 decade of 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 percent. Even if we adopt the overvaluation rate of 100 percent, 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 percent. Combining with the fact that the world rice price in the late 1960s was on the highest peak in the last four decades (Figure 1), 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 years 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 at around 1980, the heydays of the Green Revolution could be debatable. One may argue that 11 percent excess over the breakeven level would be well within a possible error margin. Another may 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 the 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 pre-Mahaweli level is of a comparative advantage.[19]

These evidences may not be sufficient to amend the statement above as follows: with the cost of new irrigation construction, the position of rice production in the major irrigation regime in Sri Lanka changed from a traditional comparative disadvantage to a comparative advantage as the Green Revolution technology diffused in the 1970s, but again returned quickly to a comparative disadvantage in the 1980s and thereafter as the potential of the technology was exhausted and the cost of new construction rose quickly due to the shift in the construction sites from easier to difficult ones. It is certainly the case, however, that the traditional comparative disadvantage was reduced significantly in around 1980 and, if rice production with constructing major irrigation schemes had ever happened to have a comparative advantage in its history, it should have been this period.

The inclusion of 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 sunk cost, the social profitability of rice production with minor rehabilitation, which was high in 1980, has eroded to the level just par between domestic production and import. The addition of major rehabilitation cost gives a similar result, though the RCR increases to a level slightly more than unity in the 1990s.

It should be remarked that the major rehabilitation cost assumed in this paper is take from a major rehabilitation project that revealed 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 percent to 250 percent 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 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

Table 8 *Net social profitability (NSP) of rice production, by irrigation regime, Sri Lanka, 1968-95*[a]

		1968		1980		1985		1990		1995	
		(Rs/mt)	%	(Rs/mt)	%	(Rs/mt)	%	(Rs/mt)	%	(Rs/mt)	%
Rice price[b]	(1)	611	100	4302	100	4173	100	6657	100	9082	100
Major irrigation											
Tradable inputs:											
Fertilizers		38	6	524	12	472	11	923	14	1038	11
Capital[c]		45	7	98	2	158	4	322	5	570	6
Others[d]		36	6	181	4	234	6	410	6	656	7
Total	(2)	118	19	804	19	863	21	1656	25	2264	25
Domestic factors:											
Labour		200	33	702	16	1138	27	1991	30	3151	35
Land		263	43	961	22	1050	25	1774	27	1813	20
Others[e]		105	17	376	9	614	15	1091	16	1627	18
Total	(3)	568	93	2039	47	2802	67	4856	73	6590	73
Total	(4) = (2) + (3)	686	112	2843	66	3665	88	6512	98	8854	97
NSP	(1)-(4)	-76	-12	1460	34	508	12	145	2	227	3
Rainfed											
Tradable inputs:											
Fertilizers				961	22	577	14	1016	15	1166	13
Capital[c]				39	1	85	2	245	4	468	5
Others[d]				290	7	243	6	504	8	792	9
Total	(2)			1290	30	905	22	1766	27	2426	27
Domestic factors											
Labour				801	19	1603	38	2946	44	4944	54
Land				894	21	1179	28	1141	17	-28	0
Others[e]				294	7	457	11	1053	16	1489	16
Total	(3)			1988	46	3239	78	5141	77	6405	71
Total	(4) = (2) + (3)			3278	76	4145	99.	6907	104	8831	97
NSP	(1)-(4)			1024	24	28	1	-250	-4	251	3

Notes: a Corresponds to the RCR of the second column of Table 7; major irrigation, with O&M cost alone. Five-year averages centering on the years shown.

b Farm-gate equivalent border price of rice (in terms of paddy) converted to rupee by SER.

c Two-wheel and 4-wheel tractors.

d Seeds, agro-chemicals and fuel.

e Buffalo, capital interests, irrigation (O&M) and domestic resource components in the marketing process of tradable inputs.

f Exclude irrigation (O&M) from footnote e.

rehabilitating the major irrigation schemes will entail a net social loss to the country, unless the efficiency of major rehabilitation projects is improved significantly.

Lastly, let us examine major factors that have brought about changes in comparative advantage in rice production. The net social profitability (NSP) of rice production is presented in Table 8 and the sources of changes in NSP are shown in Table 9. For the major irrigation regime, corresponding to the levels of RCR, theNSP is negative in 1968 and positive for all other years. The NSP was largest in 1980

Table 9 *Sources of change in net social profitability of rice production (Rs/mt) by irrigation regime, Sri Lanka, 1968-95*[a]

	1968-80	*1980-85*	*1985-90*	*1990-95*
Major irrigation:				
Change in NSP	1535	-952	-363	82
Social value added:				
Exchange rate	1787	1355	1290	1816
Rice price	1488	-1811	810	6
Input prices[b]	-290	248	-341	49
Input coefficients:				
Bio-chemical inputs[c]	-38	28	8	-19
Mechanical inputs[d]	60	-8	-75	-35
Total	22	20	-67	-55
Total	3006	-189	1691	1817
Social costs (deduct):				
Labour coefficient	-113	-171	-131	-552
Wage rate	616	606	984	1712
Land coefficient	-434	-75	-66	-89
Land rent	1132	164	790	128
Others[e]	271	239	476	536
Total	1471	763	2054	1735
Rainfed				
Change in NSP		-996	-279	501
Social value added:				
Exchange rate		1233	1267	1775
Rice price		-1811	810	6
Input prices[b]		690	-296	111
Input coefficients:				
Bio-chemical inputs[c]		181	-52	-73
Mechanical inputs[d]		-37	-106	-54
Total		144	-158	-127
Total		256	1623	1764
Social costs (deduct):				
Labour coefficient		-30	-132	-648
Wage rate		833	1475	2646
Land coefficient		-31	58	-47
Land rent		316	-96	-1123
Others[f]		163	596	436
Total		1251	1902	1263

Notes: a Based on five-year averages shown in Table 8.
b All tradable inputs combined.
c Seeds, fertilizers and chemicals.
d 2-wheel tractor, 4-wheel tractor and fuel.
e Same as the footnote e of Table 8.
f Same as footnote f of Table 8.

and has followed a declining trend since then. The increase in NSP was thus substantial between 1968 and 1980.

The most contributing factor 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 impact of a significant increase in productivity due to the diffusion of the Green Revolution technology between 1968 and 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 due to the technological advance worked in the opposite direction. In terms of Table 8, this impact of technological change is observed in the fact that the share of domestic resources in a unit of rice was reduced considerably from 93 percent to 47 percent between these two years.

From 1980 to 1985, the NSP in the major irrigation regime showed a large decline, due mainly to the decline in rice price in the world market as a result of the very success of 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 exchange rate contributed to the amelioration of the comparative advantage, while increases in the social costs counter-balance this movement.

The stagnation of yield-increasing rice technology since the mid-1980s has been evident in negligible changes in land coefficient. Instead, the reduction in labour coefficient due to the adoption of labour-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 brings down the comparative advantage of rice production in recent years. In fact, the gain from the reduction in exchange rate was nearly drained out by the increase in wage rate in 1995. A bit faster growth in the wage rate, slower improvement in labour productivity, and/or reduced pace in the depreciation in exchange rate will easily turn the balance against rice production in the major irrigation regime.

The level and changing pattern of 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. The NSP in 1980 was as high as that in the major irrigation regime. Moreover, the share in 1980 of domestic factors in rice price was as low as that in the major irrigation regime, which suggests that improvement in NSP, at a similar order as in the major irrigation regime, would have been experienced by rice production in the rainfed regime between the pre-Green Revolution period and 1980. It appears that rice farming in the rainfed regime, though handicapped in land infrastructure, also enjoyed some increase in productivity due to the seed-fertiliser technology.

In the 1980s and the 1990s, factors affecting changes in NSP were fairly common between the rainfed and the major irrigation regimes. Reflecting a higher input coefficients of tradable inputs, most importantly of fertilisers, than for rice production in the major irrigation regime, changes in their shadow prices in foreign currency had larger impacts on NSP in the rainfed regime, as was the case for

1980-1985. The impacts of increases in wage rate and in labour productivity were even more pronounced in the rainfed regime for 1990-1995. The large reduction in land rent, due to the malfunctioning of the land market, has prevented the social costs from jumping up to a level that turns rice production in the rainfed regime into a significant net social loss.

Summary and Implications

Among the developing countries in monsoon tropics in Asia, which were traditionally exporting estate crops while importing rice but have actively pursued the self-sufficiency in rice since the time of their independence in the late 1940s, Sri Lanka has attained the most remarkable success. 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 major driving forces in achieving this success. This paper has examined the level and trend in the comparative advantage of rice production in this development process.

First, it has been shown 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 due to the technological advance 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 turned it into a comparative advantage at around 1980. However, rapid cost escalation in new irrigation construction in the 1980s and thereafter resulted from the shift of construction sites from easier to more difficult ones has made new irrigation construction out of question from the comparative advantage point of view.

This finding that the promotion of rice production by means of developing new irrigation infrastructure has had no comparative advantage, with a possible exception for the period around 1980, raises a basic question as to the economic rationale of this import substitution policy in rice, which was pursued for over five decades since independence. In assessing the remarkable success in this strategic policy, it is necessary to take into consideration the economic cost that the policy incurred to the society in the form of net social loss. The fact that this policy was pursued in Sri Lanka overtly at the expense of the plantation sectors that were heavily taxed and devastated as a result (Thorbecke and Svejnar, 1987) makes this need even more important.

Second, even if we treat the cost of new irrigation construction as 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-fertiliser technology, rice production in both regimes turned to be highly socially advantageous relative to rice import. 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 impacts that the Green Revolution technology bestowed on rice production in Sri Lanka.

Third, given the irrigation infrastructure, the comparative advantage in rice production in the major irrigation regime has been 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 as well. At present, rice production in Sri Lanka is at nearly 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.

Fourth, the major factor that has been pushing down the comparative advantage of rice production is the increase in the agricultural wage rate. As the non-rice sectors, particularly the non-farm sectors, continue 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 her traditional position of comparative disadvantage in rice production. 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.*, 1998).

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.[20] In the case of Sri Lanka, however, a large increase in domestic rice production resulting from such a technological breakthrough will meet almost immediately 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 to keep domestic rice production that is economically sound is to increase labour productivity by pursuing the scale economy, which requires significant increases in farm size. This necessitates the smooth transfer of domestic resources in the rice sector, labour in particular, to the rapidly developing non-farm 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 their agricultural development, if economically 'sound' domestic rice production were to be maintained (Hayami, 1988; Johnson, 1991).

It is beyond the scope of this paper to offer prescriptions for this structural adjustment. However, it would be worth mentioning as an implication of this study that a necessary condition for this structural adjustment in the rice sector to be successful is the existence of the well-working labour and land markets, among others. The virtual non-existence of 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 temptation for the government of developing countries like Sri Lanka to resort to the argument of multi-functional values of agriculture, now advanced primarily by industrialised countries in East Asia and the European Union in the face of the trade negotiation of the World Trade Organisation, which may further blur the real need of this structural adjustment. It is the most important implication of this study that the rice sector of Sri Lanka has already entered in this difficult stage of economic development.

NOTES

1. The conceptual framework for DRC analysis adopted in this paper is essentially the same as in other two Sri Lankan studies as well as in the Philippine study.
2. See Kikuchi (forthcoming) for more details on rice production costs used in this paper.
3. There is the third regime, the 'minor irrigation' regime, the rice production cost data of which are not sufficient to make reliable estimation.
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. The selected schemes are Padaviya (Anuradhapura), Minneriya (Polonnaruwa), Gal Oya (Ampara), Minipe (Kandy), and Rajangana (Kurunegala/Anuradhapura).
6. It should be noted that fertilisers have been subsidised throughout the study period. The government fertiliser subsidy was totally withdrawn in 1990, but restored again in 1994.
7. With such symptoms as high unemployment rates in rural areas that suggest opposite, one may wonder if the assumption of well-working rural labour markets in Sri Lanka is tenable. However, recent World Bank studies (World Bank, 1995, 1996) find that the rural labour markets function far better than traditionally expected. There are some signs, beside those mentioned in these studies, which indicate rapid integration of rural labour markets into the national labour market in recent years. For example, the variation of wage rates in rural labour markets across different regions, which used to be large until the early 1990s, has been reduced 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 percent in 1990, but declined to mere 8 percent in 1995. The CV was 18 percent in 1980 and 16 percent in 1985. Therefore, we do not take such an assumption as the shadow price of labour being 60 percent of the market wage rate, the assumption made by Edirisinghe (1991) based on the convention adopted by the National Planning Division of the government.
8. Edirisinghe (1991) assumes 10 percent overvaluation of the OER around 1990, based on the information from the National Planning Division.
9. It should be noted that the rate of currency overvaluation might have been higher than assumed here. Thorbecke and Svejnar (1987), for example, assumes the rate of overvaluation at the order of more than 100 percent for the late 1960s based on the black-market exchange rate.
10. For details in the estimation of irrigation costs, see Kikuchi *et al.* (forthcoming).
11. The capital cost curve used is as follows: $\text{Ln } K = -106.3 + 0.0569\ t$, where K = capital cost per hectare of mew irrigation construction in 1995 prices (in Rs. 000) including capital interests (10 percent per year) and t = time in year (Kikuchi *et al.*, forthcoming).

12. There had been a tendency during the early 1990s that rice is substituted for by wheat in food consumption, but in most recent years the sum of rice and wheat consumption per capita has been declining.
13. Sri Lankan rice is said to have quality that does not find a large demand aboard. If so, overproduction of some significant extent may create serious pressure in the domestic rice market.
14. As will be shown later in this paper, the yield-increasing impact was significantly higher for the new-improved varieties than for the old-improved varieties.
15. The irrigation sector took nearly 40 percent of the share in the total public investments around 1950, and the share was still as high as 20 percent around 1980 (Aluwihare and Kikuchi, 1991: 12).
16. There might have been such distortion resulted from the malfunctioning of the land market in major irrigation schemes in the dry zone too, where land transactions are legally restricted. However, the evolution of 'black' land market, attested by high incidences of tenancy (Bloch, 1995) should have prevented the problem from being as serious as in the wet zone.
17. The present level of O&M expenditure per hectare of the major irrigation schemes is less than 40 percent of this 'desired level.'
18. As explained earlier, the rate of adoption of old improved varieties (H-series) that had been diffused since the late 1950s exceeded 50 percent by the late 1960s. The finding here suggests that the actual productivity impact of this H-series was not as high as that of the new improved varieties (BG series) that began to diffuse in the late 1960s.
19. The same exercise with the new irrigation construction cost of 1975 gives the RCR of 0.98.
20. This is a prescription given by Estudillo *et al.* (1998) for the Philippines.

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