

PRODUCTION EFFICIENCY IN PADDY FARMING*

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INTRODUCTION

The predominance of paddy cultivation as a major economic activity in domestic food production sector in Sri Lanka hardly needs any emphasis. The national output of this commodity has witnessed significant increases over the past two decades and this can be traced primarily to the expansion of land area cultivated as well as to increased productivity of inputs. The latter is an outcome of the application of newer research findings on a variety of aspects such as improvements in genetic constitution of the crop, introduction of superior quality fertilizer mixtures, newer methods of plant establishment, better methods of weed, pest and disease control, etc. A majority of such innovations originating from research institutions primarily seek enhanced crop yields by application of better production methods which are technically efficient. However, it is to be noted that all these production techniques do not necessarily guarantee the most economic means of resource use at the farm level representing the highest economic efficiency where maximum paddy output is produced using a minimum of production inputs. Therefore, an evaluation of the degree of economic efficiency associated with the production of this crop forms an important area of research investigation. It is only recently that in Sri Lanka, economists have evinced some interest on this aspect and so far systematic investigations on these lines are few.

This paper attempts to analyse the level of efficiency in production and research allocation in paddy farming through an investigation of underlying input-output relationships. It is hoped that the study results would assist in further understanding of the allocative behaviour of paddy farmers and hence set useful guidelines for readjusting the existing resource allocation pattern at the farm level as a means of increasing production.

STUDY OBJECTIVES

The study aims are:

- i. to determine the productivity coefficients of major production resources;
- ii. to measure the gap between existing and optimal levels of resource use on sample farms and, thereby show the degree of economic efficiency of resource utilisation.
- iii. to determine appropriate economic adjustments in the existing stock of resources from the standpoint of maximising profits at the farm level.

* This paper draws extensively on the author's unpublished MSc thesis entitled "A Production Function Analysis of Paddy Farming in Sri Lanka" University of British Columbia, Canada, 1976.

DATA

This analysis is based on data gathered from a sample of 107 rice farms in Polonnaruwa, Hambantota, Kurunegala, Kandy and Colombo districts. The period under consideration is Maha 72/73. The sample selection was made on a judgement basis to represent a cross section of the important paddy production situation and all farmers concerned had rice crops as their major enterprise. With a view to obtaining precise farm data, a continuous data monitoring exercise was conducted in selected farms using farm records. Hence, the level of cooperation extended by the individual farmer constituted an essential prerequisite of the exercise. The analytical approach adopted in this study follows an aggregation of farm level data from a number of different districts. In order to avoid any possible limitations arising out of such aggregation an alternative approach of a districtwise analysis would have been followed, which however, calls for a larger farm sample than used here.

CONCEPTUAL MODEL AND STUDY VARIABLES

The main analytical tool employed here is the technique of production function analysis, whereby the associative effects of inputs are expressed in terms of regression coefficients.

The algebraic relationship between the paddy output and the production inputs can be represented by a simple production function model such as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, S)$$

where Y is the paddy output, X_1 represents the relevant production inputs and S signifies a random variable consisting of a whole array of influences, such as climatic, geographical, social and such other factors. Even when S is not measured, the regression analysis still permits statistical estimates to be made of Y, through the assumption of normally distributed mean-zero error terms around the line of regression.

The output (Y) was measured in terms of the value of paddy produced per farm. In many cases where domestic consumption as well as payments in kind accounted for a substantial portion of farm output, the valuation of such items was based on the existing market prices.

Land input (X_1) was measured by the physical extent cultivated by the farmer, in acres. Labour variable (X_2) was incorporated in terms of man-day equivalents of work input, taking 8 hours of labour as a work day. In computing the equivalent man-day input of work per farm, one woman-day and a child-day was considered as being equivalent to .75 and .50 of a man-day respectively. These indices were based on the modal wage rates prevailing in the area. Fertilizer input (X_3) represents the cost incurred per farm for purchasing the fertilizer applied during the season. The input representing tractor services (X_4) includes the value of tractor services used per farm for paddy production including the cost of operator services. Whenever farmers used their own resources, an imputed value based on the usual hire charges prevalent in the area was used. The variable used to represent the animal services (X_5) includes the value of using buffaloes as well as the value of the operating labour. The usual approach of measuring this variable is to assess the value of buffalo service independently from that of attending human labour. However, it seems logical to consider the services of both buffalo and

its attendant labour as a single production factor since they essentially complement each other. The draft services input (X_8) formed another variable specified by the summation of (X_4) and (X_5). Hence (X_8) represents the total value of buffalo services plus tractor services utilised per farm for paddy cultivation. Owing to a variety of chemical inputs such as weedicides, pesticides, fungicides, etc., used for crop protection, the variable (X_6) representing agrochemicals was measured in terms of the total value of such inputs applied per farm. In all instances where farmers utilised their own inputs such as family labour, owned buffaloes and tractors etc., an imputed value was used on the market prices prevalent in the area.

RESULTS AND DISCUSSION

Using different specifications of the above regression model, a number of regressions in both multi-linear as well as the log-linear equational forms were estimated. However, evaluations based on the parameters of these functions showed that the best statistical fit to the farm data was given by the Cobb-Douglas type of production functions among which the most appropriate was judged to be the following:

$$Y = 17.2187 X_1^{.2570*} X_2^{.5987*} X_3^{.2030*} X_8^{.1272**} \dots (1)$$

$$R^2 = .92$$

* significant at .01 level

** significant at .05 level

The particular combination of land, labour, fertilizer and draught power variables given above equations in the log-linear form is capable of capturing almost all of the variations in the farm output. All regression equations used to represent different production models indicated that the variables representing tractor power (X_1) and animal power (X_2), expressed their best in the production function in the form of a joint variable (X_8). Whenever (X_1) and (X_2) are included separately in the regression the results showed that one of them turned out to have a negative coefficient. This perhaps is an indication that in this particular instance variables (X_1) and (X_2) cannot be taken as two separate groups of production inputs but in fact form a single variable representing the draught power input (X_8). Another notable feature in the above production function may be the non-inclusion of agro-chemicals variable (X_6). The different production function models used showed that this variable even when included in the function did not add substantially to its explanatory power and at the same time showed a statistically insignificant coefficient. Hence, judging by their parameters it was felt best to exclude this variable from the function. Most certainly, a measurement or any other specification problem of this variable would have led to this problem. However, equation (1) by itself is a satisfactory model of the paddy production for further analysis.

RETURNS TO SCALE IN PADDY FARMING

In the present case, the measure of returns to scale as deduced from the function amounts to 1.2. In simpler terms, this implies that if each of the production inputs in paddy farming is subjected to a simultaneous increase

of one per cent, it would follow a specific output increase of 1.2 per cent. The findings therefore suggest that among the cross section of paddy farmers investigated, an almost constant return to scale is operational.

MARGINAL VALUE PRODUCTIVITY (MVP) OF INPUTS

The estimate of MVP's of production inputs of a paddy farm at the geometric mean input levels are given in the Table 1 below. MVP of an input is defined as the addition to the total value product resulting from the addition of another unit of input to the production process, *ceteris paribus*.

TABLE 1 Levels of Geometric Mean Input Application per Farm and the Marginal Value Productivities of Paddy Farms

Resource	Geometric Mean Input per Farm	MVP (in Rupees)
Land	1.8 (Acres)	220.43
Labour	104.0 (Man-days)	8.89
Fertilizer	30.50 (Rupees)	3.89
Draught services	199.50 (Rupees)	0.99

From the above, it is evident that the value productivity of an acre of paddy land at the margin during the 72/73 Maha season is Rs. 220.43 while that of a man-day equivalent of work input is Rs. 8.89. The results also reveal that each rupee invested in fertilizer and draught services inputs would have brought an additional amount of paddy worth Rs. 3.89 and Rs. 0.99 respectively.

INPUT ALLOCATIVE EFFICIENCY

In the absence of capital limitations or any other relevant constraints on the application of an input, the most efficient level of allocation of an input is given by the condition of equality between its own marginal value product (MVP) and the marginal factor cost (MFC). In other words, a ratio of 1 between its MVP and MFC would indicate that in terms of economic criteria, the most optimal allocation of the production resource had been achieved. Any value taken by this ratio other than unity is indicative of a resource maladjustment. A condition of MVP greater than MFC implies an under-utilisation of the resources while instances where the MFC is greater than MVP indicates an over-utilisation. The empirical results of comparing MVP's and MFC's of the paddy production inputs are given in Table 2.

The ratio of MVP to MFC for each resource given in column 4 of Table 2 was statistically tested with respect to the null hypothesis that the ratio equalled one. The results revealed that the ratio for land and draught services input were not rejected as being equal to one and hence in a restricted equilibrium sense these two inputs show efficient allocation or optimal use. However, in the case of labour and fertilizer the ratios were rejected as being equal to one. Here, the MVP's are substantially higher than their corresponding MFC's and this situation is more acute in the case of fertilizer than in the labour input. The data is therefore indicative of a substantial under-application of fertilizer and labour. Farmers could have afforded to use these two resources more intensively than at present, to their advantage. It is noteworthy that in none of the input groups considered had there been evidence to show that farmers are over-utilising their resources.

TABLE 2 Comparison of Marginal Value Productivities and Marginal Factor Costs of Inputs in Paddy Farming at Geometric Mean Levels of Application — Based on Equation (1)

Production Input		MVP _i (Rs)	MFC (Rs)	Ratio of MVP to MFC	Geometric Mean Input Level
X ₁	Land (Acres)	220.43 (19.71)	227.50	.96	1.8
X ₂	Labour (man-days)	8.89 (0.73)	6.10	1.46*	104.0
X ₃	Fertilizer (Rs.)	3.89 (0.14)	1.00	3.89*	80.5
X ₄	Draft services (Rs)	0.99 (0.60)	1.00	.99	199.0

Figures in parenthesis indicate the standard errors of MVP estimates.

* Null hypothesis that ratio equals 1 was rejected at 1 per cent.

The standard error of MVP estimate of each production input was calculated from the formula,

$$\text{SEP} = \frac{Y}{X} \cdot \frac{S_b}{X_i}$$

where Y is the geometric mean value of output, X_i is the geometric mean value of input, and S_{bi} is standard error of the regression coefficient b_i with regard to X_i. See E. O. Heady and J. Dillon, **Agricultural Production Functions**, Iowa State University Press, 1961, p. 231.

Since all the MVP estimates were made at the input geometric mean levels using the Cobb-Douglas function, the more complex variance formula for determining the standard errors of estimate developed by Carter and Hartley was not applied. See H. K. Carter and H. O. Hartley, "A Variance Formula for Marginal Productivity Estimates Using the Cobb-Douglas Function", *Econometrica*, 26: April, 1958, pp. 306—313.

The situation of sub-optimal allocation of fertilizer perhaps poses a simpler case to understand considering the usual capital rationing as well as the difficulties of input procurement faced by many farmers. However, the farmers' level of expectations consistent with the relatively high risk of production may also be cited as a significant factor explaining the application of sub-optimal levels of fertilizer. In their production environment — with substantially high risk factors, even if the potential benefits of fertilizer are known, farmers may show an aversive reaction to using optimal fertilizer levels. It is also conceivable that a deficient farmer knowledge regarding fertilizer use could also contribute to the state of under-utilisation observed in this study.

The state of labour utilisation at levels significantly below the optimal quantities may, however, seem difficult to reconcile at first sight. This is particularly so, in the light of high rates of unemployment usually prevalent in the rural sector which makes the MVP of rural labour in these economies to be zero or near zero. The usual argument for such an assumption of a zero or near zero MVP for labour is that a surplus of farm labour exists and the lack of alternative means or employment in the peasant sector ensures conditions whereby it is readily employed to the point of zero MVP.

Despite such arguments, the relatively high MVP of labour engaged in paddy cultivation in the present case can still be satisfactorily explained in terms of its marked seasonality in labour application in paddy cultivation. Examination of the labour profile of paddy cultivation typically shows at least two critical periods of heavy labour demand during the initial land preparation as well as during the final production phase including harvesting and threshing. These operations are extremely time specific and require completion within a short span of time. During these peak periods, family labour alone is hardly adequate to perform certain tasks such as land preparation and harvesting. Hence such tasks in particular call for additional supplies of labour outside the farm to augment the available farm family labour and as a consequence the phenomenon of using hired labour is common even in smaller paddy farms. It occurs in relatively greater magnitudes in major paddy districts where the crop is grown on a large scale. During the peak labour demand periods and the farmers therefore could experience constraints of labour supply which may compel the farmer to use a lesser amount of labour than desired. In fact, in some of the major dry zone paddy areas such as Polonnaruwa, and Hambantota, during the peak labour demand periods, there exists a floating labour force migrating from other densely populated areas in the wet zone where there are relatively less opportunities for employment. Hence this observation also substantiates the hypothesis of the existence of labour constraints in paddy production in this country even at the present stage of development.

IMPLICATIONS OF THE FINDINGS AND POLICY RECOMMENDATIONS

The study results pinpoint that within the framework of existing production constraints such as irrigation water shortages, input supply problems, etc., paddy farmers under consideration had adapted reasonably well to use their resources in command at optimal levels and thereby displaying a striking level of economic rationality. This is contrary to the widely held belief that the small farmer in a subsistence economy is conditioned mainly by non-economic factors. The high level of economic rationality displayed by the paddy farmer is attributable to their long experience and association with the cultivation of this crop. Given the circumstances in which they operate, producers through their intuition seem to judge the optimum levels of application of their resource inputs fairly well. The analytical results in this study hence are in conformity with the view that peasant farmers cultivating paddy are in fact "economic-men" who are responsive to economic criteria. It is most interesting to observe that despite their subsistence orientation these paddy producers are reasonably responsive to economic incentives offered. Therefore, provision of suitable economic opportunities would in fact be used as a useful policy tool for motivating the average Sri Lanka paddy farmer to respond favourably to the development objectives. Furthermore the analysis also indicates some useful guidelines for policy directions.

EFFECTIVE FARM FINANCING

The results of the study also highlighted some maladjustments in farm resource application and as already mentioned the capital constraints may explain this to a large extent. The modern methods of paddy farming are inevitably cash intensive and this demands increased capitalization of the paddy farms at specific times during the cultivation period. The importance

of the provision of required capital for increasing productivity had been repeatedly stressed even in the past and various remedial measures had been adopted. However, the results of this analysis pinpoints that these problems are still not resolved satisfactorily but continues yet as major bottlenecks hindering the efficient application of inputs.

Although a full discussion of farm financing aspects is not intended here, it seems fitting to comment on a major aspect of this subject that has so far been largely overlooked. This constitutes the risk side of paddy farming which requires careful attention for efficient operation. The arguments in this regard can be briefly summarised as — a development necessitates new techniques and production inputs; these are viewed by the farmers as associated with a risk element; in general, farmers whose production goals are mainly subsistence are particularly risk averse; therefore, if inputs are to be obtained through credit, risk perception is an important impediment to expanding farm production. This line of argument emphasises that the expansion of credit schemes for financing farm needs has to be supported by other complementary programmes such as crop insurance, provision of assured irrigation, etc., which would lower the risk levels faced by the paddy grower.

PROVISION OF ADEQUATE FARM POWER

A major suggestion emanating from the present analysis concerns an under-application of manual labour in the paddy sector of Sri Lanka. This has been discussed in some length previously for which a shortfall of labour supply during the peak demand periods was offered as a plausible reason. The use of appropriate forms of farm power to augment the human labour supply on paddy farms would therefore form a crucial issue to be considered by the policy makers. In fact many paddy areas of Sri Lanka seem to suffer a scarcity of draught power and it is most likely that in future the problem may attain greater magnitude at least due to two major considerations, i.e. (a) increased cultivation both due to expansion of acreage under new irrigation schemes and changes in cropping intensity (b) dwindling of buffalo population due both to increased slaughter rates as well as to diminishing grazing land. Since mechanization per se in a peasant economy is inherently associated with certain negative social consequences the necessity for pursuing an appropriate strategy with a right farm-power mix can not be over stressed.

INCREASED FERTILIZER USE

Fertilizer input is one of the "essentials" in the package of modern inputs that play a crucial role in raising yields. However, the present level of its application is far below the economic optimum as clearly evident from the MVP estimates. In fact, figures on fertilizer use at the national level also indicates that the present level of application of fertilizer in paddy is only a third of the desired target. In addition to capital constraints there seems to be a number of other factors responsible for such sub-optimal levels of fertilizer application by farmers. This may be viewed more carefully in relation to the State subsidy on this item. If the subsidy offered to the producer is removed either partially or wholly, the consequent increase in fertilizer price would at least have two important negative repercussions on the economic levels of fertilizer application in the farm. The resulting increase of farm price would not only lower the optimum quantity to be

applied per acre but would also reduce the quantity that would be applied due to the contraction of the farmers' purchasing capacity. Since even at present, the quantity applied is substantially below the economic optimum level it is necessary to study the problem in detail for suggesting suitable remedial measures.

INVESTMENTS IN FARMER EDUCATION

As common to many other sectors in the economy, production technology in paddy also is in a state of flux due to a continuous flow of new information channelled from the research institutions. Hence for obtaining the economically best results from the application of newer types of production inputs, the demands made on the decision making and managerial skills of the farmers would be considerable and exacting. An economic rationality could only be exercised by the grower only under conditions of full information and a lack of free information flow between the farmer and the research centres would undoubtedly lead to a mis-allocation of production resources. Hence, in this regard the necessity to keep the farmer fully aware of the new technological information through an efficient extension network cannot be overemphasised. In this particular study, it was seen that two of the major resources, labour and fertilizer are substantially under-utilised and one contributory factor for this situation is perhaps a lack of adequate knowledge by the farmer.

In fact, the evidence for a strongly positive relationship between agricultural production and farmer education had been well established by a number of studies elsewhere. These have shown that farmer education is one of the high pay-offs inputs in agriculture and the cost-benefit considerations of these studies estimate that the benefits accruing to farmer education are high by most standards. Such high returns to education arise basically from upgrading the quality of labour input. In the light of these it can be suggested that as one important means of increasing productivity in paddy farming is also to make increased investments in farmers education programmes.

REFERENCES

1. Abeysekera, W. A. T. (1976) **Production Function Analysis of Paddy Farming in Sri Lanka**, unpublished MSc. thesis, University of British Columbia.
2. Amerasinghe, N. (1976) **Economic Resource Use and Decision Making in Paddy Farming in Some Mid Country Villages of Sri Lanka**, Faculty of Agriculture, University of Sri Lanka.
3. Ranatunga, A. S. and Abeysekera, W. A. T. (1978) **Resource Use and Profitability in Paddy Farming**, Agrarian Research and Training Institute.
4. Schultz, T. W. (1964) **Transforming Traditional Agriculture**, New Haven: Yale University Press.
5. _____ (1963) **The Economic Value of Education**, New York: Columbia University Press.