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**EFFECT OF FARM-LEVEL CONSTRAINTS, EXISTING AND PROSPECTIVE POLICIES ON
EXPANSION OF COCONUT-BASED INTERCROPPING IN SRI LANKA**

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Abstract

Coconut-based intercropping (CBI) in Sri Lanka was introduced some 20 years ago to overcome the two main limitations of traditional coconut monocropping, inefficient land use and low incomes to farmers, but it has not been widely adopted. This study analyses the effect of farm-level resource constraints, and government policies on the intensity of adoption of CBI. A multiperiod linear programming (MLP) model was applied for three farmer groups - resource poor, medium endowed, well endowed - categorised using cluster analysis. Data was collected from a survey of randomly selected 113 intercroppers.

Empirical results reveal that expansion of CBI is mainly constrained by seasonal labour shortages for all farmer groups, particularly the well endowed, and by the scarcity of cash in the case of resource-poor farmers. CBI policies aimed at subsidising inputs or intercrop prices are not likely to be efficient in raising adoption, but alternative policies aimed at alleviating resource constraints would be more effective.

The study concluded that the low adoption of CBI is mainly attributable to the scarcity of different farm-level resources (other than land), at varying degrees among different farmer groups. Hence a targeted approach to alleviate them is suggested.

Introduction

Coconuts are the second most important crop in Sri Lanka after rice, occupying 25% of cultivable land and making the greatest contribution to GDP of plantation crops. Originally a plantation crop, coconuts have a productive life of over 60 years with a low labour requirement of 0.25 worker/ha/year. The crop has become popular with peasant cultivators and is now principally a smallholder's crop with 75% of the coconut area in holdings less than 8 ha.

Coconut-based intercropping (CBI) in Sri Lanka is important for two main reasons. First, coconut monocropping is less profitable than the intensified land use system of CBI. Second, per caput arable land availability is rapidly declining due to the increasing population and the use of cultivable (mainly coconut) lands for industry, housing and roads. Coconuts must be spaced at about 8 m due to the leaf canopy between years 5-8 and 20-25. Up to year 5-8 and after year 20-25 they do not fully utilise the space, the root bole being 2m around the tree, thus intercropping is possible with 75 % of the area and 44% of the radiation unutilised. If the intercrops are correctly fertilised there is actually an increase in coconut yield.

Policies of the Sri Lanka government aimed at expanding CBI have included:-

- a) **An intercropping subsidy** given only in kind, i.e. planting materials and fertiliser, for intercrops such as coffee, pepper, cocoa, lime, lemon, banana, pineapple, passion fruit and pawpaw.
- b) **A fertiliser subsidy** of 50% of the import price of fertiliser as a direct payment to importers from 1972-1989 and again briefly in 1994.
- c) **Subsidised credit** interest rate of 14% including for, increasing perennial and semi-perennial crop production, optimising land use, and increasing farm income.
- d) **Extension services** to provide advice promote intercropping and administer subsidies.

Despite government promotion of CBI for nearly two decades, only 25% of the potential area is intercropped. The results reported here, are part of a study of the socioeconomic reasons for the poor uptake of CBI by smallholders in Sri Lanka.

The aggregate area of CBI depends upon the incidence of CBI i.e. the number of farms intercropping and the intensity or proportion of land intercropped by intercropping farmers. Low levels of both the incidence and intensity of CBI on farms contribute to the aggregate low level of CBI. The objective of this paper was to identify the reasons for the low *intensity* (rather than *incidence*) of CBI at individual farm level.

Specific objectives were:

- i) to identify and quantify the farm-level resource constraints of the present intercroppers
- ii) to analyse the effectiveness of existing government intercropping policies.
- iii) to identify prospective policies and their likely effectiveness in increasing the *intensity* of CBI

Hypotheses based on these objectives included the following:

- i) Farm-level resource constraints of intercropping are: the coconut area farmed, family and hired labour available for farm work, and the availability of cash.
- ii) Existing CBI policies are not effective in increasing the *intensity of adoption* and farm income.

- i) Policy changes could increase the intensity of CBI.

Model

113 smallholders who intercropped were surveyed in detail by interview (Fernando et al 2003). From this data a Multi-period Linear Programming (MLP) model was developed for each of three farmer groups (resource-poor: Group 1, middle-income: Group 2, affluent: Group 3), categorized using cluster analysis. Table 1 shows some of the features of the groups.

Table 1 Principle features of the Cluster Groups of surveyed farmers

	<i>Group 1 Resource-poor</i>	<i>Group 2 Middle-income</i>	<i>Group 3 Affluent</i>
Family Labour for farm work man days/year	295.3	217.4	163.3
Coconut area ha	3.73	9.9	15.5
% of land intercropped	48.4	43.0	37.0
Rice land area ha	1.08	1.59	2.02
Total Income Rs/year	163,854	322,821	571,672

BASIC STRUCTURE OF THE MODEL

Variables included were intercropping, rice farming, maintenance of existing coconuts, off-farm work, labour hiring, cash borrowing and paying family living expenses.

Objective function

The objective function was formulated to maximize the present value of future incomes at a 10% real rate of risk discount rate.

Planning horizon

With crops growing for five years the planning period was nine years.

Objective function entries

The entries in the objective function in each year were the discounted values of: a) gross margins of alternative production activities, b) variable cost of rice growing and maintaining of existing mature coconuts, c) selling price of rice and coconut, d) wage rates for hired labour and off-farm working, and e) interest rates on loan. A complementary effect of intercropping on coconut yield was included. The MLP maximizes the total Present Value of future incomes over the nine years.

Constraints in the model

These comprise: land, labour, own capital, borrowing capital, an equality constraint to meet the minimum household expenditure, an equality constraint forcing the cultivation of rice to meet the household demand, agronomic restrictions, continuation of the existing coconut palms. These were different for the three farmer groups.

Seasonality of labour

Four seasons of labour demand were identified, namely S1 (October - January), S2 (February - April), S3 (May - July) and S4 (August - September). Family and hired labour availability in each season of each year was computed.

Coefficients

For each activity the unit values and coefficients of resource use were based on the survey (Fernando 2003) and research data from the Coconut Research Institute

Results and Discussion

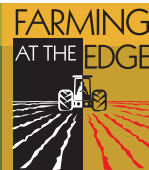
i) Model Results

Table 2 shows the model solutions which identify the constraints for the expansion of existing CBI under the current policy setting – i.e. in the absence of fertiliser subsidy, at prevailing market interest rates on loans, etc.

Table 2 Base model solutions for three farmer groups

Attribute	Farmer Groups		
	Group 1 Resource-poor	Group 2 Middle-income	Group 3 Affluent
Optimal crop plan	Initial periods dominated by labour-intensive betel; cash-intensive crops (pineapple) entered	Farm plan dominated by cash-intensive crops (e.g. pineapple)	Labour-intensive betel not planted frequently; cash intensive pineapple enters the

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	towards the end of planning horizon		farm plan frequently
9 year discounted annual income (10%)	Rs 168 532	Rs 247 053	Rs 265 168
Level of off-farm activities	Off-farm working in all seasons of first two periods, but declines in later periods	Less allocation of family labour for off-farm work than Group 1	No family labour in off-farm work
Resource Use			
- highland	Highest use of highland for intercropping (97%) in period 8	Highest area attained under intercropping is (48%) in period 6	Highest area under intercropping (33%) in period 6
- lowland	Rice growing (0.31 ac) in each of 9 periods	0.36 ac required for rice consumption	0.26 ac required for rice consumption
Labour			
- family labour	Slack in early periods, binding in later periods	Always fully used	Always fully used
- hired labour	Slack in early periods	Always fully utilized in S4	Always fully utilized in S4
Capital			
	Binding from the first to third period	Binding only during the first period	Constantly in surplus supply
Credit			
	Fully used up to the third period	Some borrowing in the first period	No borrowing

Note: 1 US \$ = Rs 96 on 22.11.2002.

Group 1 (Resource-poor farmers)

- Due to scarcity of cash, expansion of intercropping takes place slowly in the first three periods. As cash is generated, land is almost fully (97%) used for intercropping towards the end of the planning period. Thus, land may become limiting.
- After period 3, family labour is fully used in all but S2, when slack labour is used for off farm work, and has a high Marginal Value Product (MVP) in S4.
- Hired labour is completely used up in S4 and some used in S1 after period three. The MVPs of hired labour in scarce seasons are greater than the market wage rate
- Rice-growing constantly competes especially for family labour.
- Cash is scarce and credit fully utilised in the first three periods when the MVP of cash is higher than the current market-borrowing rate but is surplus thereafter, implying that the provision of credits at current market borrowing rate could expand intercropping.

Group 2 (middle-income farmers)

- Land is not binding as only 48% of the potential used for intercropping.
- Rice growing competes for family labour.
- Family labour is constantly binding.
- Labour allocation for off-farm work is reduced, as the opportunity cost is high.
- Hired labour is substantially used in S1, is binding in S4 throughout, and the MVPs are higher than the market wages.,
- Cash is in short supply only in the first period, and credit supply not fully utilised due to labour scarcity

Group 3 (affluent farmers)

- Only 33% of the potential land used for intercropping.
- Family labour allocation for off-farm work is the lowest of the groups.
- Family labour is binding throughout.
- Hired labour is substantially used in S1, is binding in S4 throughout, and the MVPs are higher than the market wages.,
- Cash is in surplus in every period and no loans are taken out as labour is binding.

Sensitivity Analysis

In terms of land used for intercropping, and farm income five scenarios were examined (Table 3)

- a) An optional “rice buying” activity was included to **relax the rice growing constraint**. All groups shift from rice growing to rice-buying, although Group 1 only after period 3 when cash has been generated. This increases the intercropping and the income.

- b) Off-farm income may act as a risk-spreading mechanism. With no off-farm work total income is reduced, limiting cash so intercropping is reduced especially for Group1, and risk is increased.
- c) Increased wages, resulting from labour scarcity, reduces farm income and increases intercropped area with a move to more extensive less labour demanding crops.
- d) Labour-saving farm mechanization could increase the availability of family labour which was therefore scaled upwards and downwards by 10, 25 or 50 per cent. Increased supply of family labour increases the intercropping and farm income in all three groups.
- e) The availability of hired labour was scaled upward and downward by 10, 25, and 50%. Increased labour greatly increased intercropping and farm income especially for Groups 2 & 3.

Table 3 Results of sensitivity analysis (% of base model results)

Scenario	Attribute	Farmer Groups			
		Group 1 Resource- poor	Group 2 Middle- income	Group 3 Affluent	
Relaxing compulsory rice-growing constraint	Intercropped land	+ 3.6	+ 7.8	+ 4.0	
	Farm income	+ 3.8	+ 5.0	+ 3.5	
Absence of off-farm work opportunities	Intercropped land	- 13.0	- 9.0	- 3.0	
	Farm income	- 3.3	- 0.1	- 0.0	
Increased wages for hired labour	by 10%	Intercropped land	+ 4.9	+ 3.9	+ 1.3
		Farm income	- 0.2	- 1.0	- 1.1
	by 20%	Intercropped land	+ 4.9	+ 13.6	+ 13.2
		Farm income	- 0.3	- 1.8	- 2.0
	by 30%	Intercropped land	+ 4.8	+ 13.6	+ 20.0
		Farm income	- 0.4	- 2.5	- 3.0
Varying the availability					

of family labour				
by +25%	Intercropped land	+ 1.7	+ 4.9	+ 4.7
	Farm income	+ 13.5	+ 9.6	+ 6.7
by +50%	Intercropped land	+ 27.0	+ 10.3	+ 8.3
	Farm income	+ 1.7	+ 19.1	+ 13.4
by -25%	Intercropped land	- 12.0	- 5.4	- 5.3
	Farm income	- 14.0	- 9.6	- 6.7
by -50%	Intercropped land	- 26.0	- 12.0	- 11.0
	Farm income	- 29.0	- 19.2	- 13.5
Varying the availability of hired labour				
by +25%	Intercropped land	+ 1.7	+ 27.0	+ 28.2
	Farm income	+ 8.7	+ 16.3	+ 18.5
by +50%	Intercropped land	+ 4.0	+ 53.8	+ 56.4
	Farm income	+ 17.0	+ 32.7	+ 37.0
by -25%	Intercropped land	- 20.0	- 27.0	- 29.3
	Farm income	- 8.7	- 16.4	- 18.5
by -50%	Intercropped land	- 33.0	- 55.0	- 60.0
	Farm income	- 18.0	- 32.9	- 37.0

ii) Policy Analysis

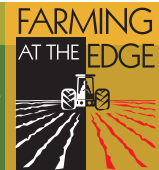
In terms of intercropped area and farm income, the impacts were explored of a fertiliser subsidy, intercropping subsidy, price support for intercrop output, increased access to loans at the current market borrowing rate, and a subsidised credit scheme with increased availability (Table 4).

A switch to more extensive intercrops may represent an increase in intercrop land use, but not necessarily the intensity of intercropping, whereas a shift to more intensive crops may decrease the area intercropped, especially if labour is binding. Thus some changes may increase farm income yet reduce the intercropped area. The area intercropped may therefore be a poor indicator of intercropping intensity.

Table 4 Results of policy analysis (% of base model results)

Policy	Attribute	Farmer Groups		
		Group1	Group 2	Group 3

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Reinstating the subsidy on fertilizer	Intercropped land	+ 8.8	- 6	- 10
	Farm income	+15.6	+ 8.7	+ 9
Intercropping subsidy	Intercropped land	- 18	- 35	- 44
	Farm income	+ 9.3	+ 3.6	+ 3.4
Increased output price by 10%	Intercropped land	- 0.1	- 10	- 11
	Farm income	+ 18	+ 14	+ 15
by 20%	Intercropped land	+ 5.5	- 7.5	- 10
	Farm income	+ 35	+ 30	+ 31
by 30%	Intercropped land	+ 2.6	- 5	- 10
	Farm income	+ 51	+ 45	+ 46
Combined effect of output price increase by 10% + increased supply of family and hired labor in S4 by 10%	Intercropped land	+ 3.8	+ 8	+ 0.9
	Farm income	+ 26	+ 24	+ 25
by 20%	Intercropped land	+ 21	+ 65	+ 33
	Farm income	+ 32	+ 40	+ 33
by 30%	Intercropped land	+ 29	+ 99	+ 63
	Farm income	+ 38	+ 48	+ 40
Increased availability of loans by +25%	Intercropped land	+ 8.7	A	B
	Farm income	+ 10	A	B
by +50%	Intercropped land	+ 25	A	B
	Farm income	+ 18	A	B
by +100%	Intercropped land	+ 30	A	B
	Farm income	+ 24	A	B
Subsidized credits	Intercropped land	- 0.6	0	No effect
	Farm income	+ 0.7	+ 0.1	No effect

Increased supply of subsidized credits

by +10%	Intercropped land	- 0.6	C	No effect
	Farm income	+ 0.7	C	No effect
by +50%	Intercropped land	+ 23	C	No effect
	Farm income	+ 19	C	No effect
by +100%	Intercropped land	+ 34	C	No effect
	Farm income	+ 25	C	No effect

Notes: A - There are unutilized loans in the base scenario, and so this policy was not explored further.

B - Farmers did not borrow any money in the base model because cash was surplus during the entire 9-year planning horizon.

C - Since the level of loans taken was less than their availability, there is no benefit from increasing the supply of low-interest loans.

The policies examined accelerate the early expansion of intercropping, but make fairly small changes over the nine years as labour is binding. Input subsidies and price support policies raise farm income, but their impact on expanding the CBI is small or negative in all three groups. Fertiliser subsidies work better than output subsidies which, for the more affluent farmers, provide a greater absolute increase in income. Simultaneous increases in CBI and farm income require increasing seasonal labour, or raising labour productivity in peak periods and for Group 1 providing credit

Discussion and Conclusions

Lack of credit for Group 1 in the initial years is a problem while Group 2 use some additional credit. There is only a marginal additional response if the credit is subsidised. With credit available, Group 1 may utilise all the available land. For all groups, labour is binding particularly in S4 when rice harvest and intercrop work clash, but particularly for Groups 2 & 3. Alleviating these would work much better at increasing both intercropped area and farm income than the subsidies that have been tried, which do increase farm income and so have been popular with farmers.

Group 1 farmers are least likely to have adequate collateral for credit and may default on loans as has often happened with previous agricultural loan schemes. Intercropping is not without risk of disease, pests, weather and price fluctuations, which might affect the ability of Group 1 farmers to repay credit. Family labour availability is constrained by rice production and rice harvest is perhaps more easily mechanised than intercrops. Existing machinery sharing arrangements might be improved and research and development devoted to appropriate rice production mechanisation, (e.g. rice harvesters) to release labour for intercropping. Moisture conservation measures would spread the working

season and also needs investigation. Hired labour is available but many workers prefer non agricultural employment. Group 3 includes professional and other occupations who have neither time nor expertise to intercrop themselves. Their present practice of taking landless labourer families from rural areas and settling them on their farms works well, providing labour for farm work on a regular basis. However tenancy laws can lead to tenants claiming ownership, which creates a reluctance to offer tenancies or share cropping.

This study shows that even within the smallholder sector there are distinctly different groups whose constraints and responses differ. Therefore differential targeting of policies may be required. Policies, which improve income may be popular with the farmers but may not increase intercropping if other resources are limiting expansion. The results of the MLP reveal that expansion of CBI is mainly constrained by seasonal labour shortages for all farmer groups, particularly the affluent Group 3, and by the scarcity of cash in the case of resource-poor farmers Group 1. CBI policies aimed at subsidising inputs or intercrop prices are not likely to be efficient in raising adoption; policies aimed at alleviating resource constraints would be more effective. This study has demonstrated the usefulness of MLP for providing guidelines for policy.

Biographical Details

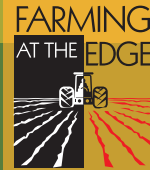
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