

## Classification of Farmers Adopting Coconut-based Intercropping Systems in Small-holdings Using Cluster Analysis

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### ABSTRACT

Due to the variability of individual farms in the smallholder coconut sector, application of the same development strategy to the entire smallholder sector is not appropriate. This study classifies the smallholder coconut-based intercropping farmers into homogenous groups using cluster analysis. Data were collected by a field survey of 113 farmers adopting coconut-based intercropping systems. The survey was conducted from March to May 1995 in three main coconut growing districts in Sri Lanka, namely Gampaha, Kurunegala and Puttalam. Three recommendation domains representing resource-poor, middle level and affluent farmers were identified even among the so-called coconut smallholders. The study established the existence of heterogeneity among smallholder coconut farms, which are frequently considered as homogenous for formulating development strategies and technology recommendations.

### INTRODUCTION

The values taken by such variables as soil type, farmers' age and experience, the availability of capital etc. characterize individual farms and variation in only a few of these makes each farm unique (Dent, 1975). The diversity of these variables also influences the adoption of a technology to varying degrees. In view of this variability of individual farms in agriculture, application of the same development strategy to the entire farming sector is inappropriate. Applied to the coconut industry in Sri Lanka, considering the entire coconut smallholder as a homogeneous farm for technical recommendations is not acceptable in view of the wide diversity observed in relation to the internal economic circumstances<sup>1</sup> (land, labor, capital and objectives) of smallholder coconut farmers. In order to apply the same development strategy generally to a large number of farms, regrouping the farm types is necessary. Such a regrouping

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<sup>1</sup> A full account of farmers' circumstances will be found in Byerlee *et al.* (1980). Planning Technologies Appropriate to Farmers: Concepts and Procedures, CIMMYT, Mexico.

facilitates the application of appropriate strategies to different groups. As pointed out by Manyong *et al.* (1988), “the best procedure for this regrouping is to distinguish between all individuals, thus leading to as many development strategies as there are production units”. Applied to the present purpose, different development strategies would have to be adopted for each coconut farmer in the smallholder coconut sector, as their circumstances are diverse. This approach is however prohibitive due to the high costs involved. When individuals among whom few differences prevail are regrouped in the same category, some loss of information would occur. However, it ensures that the farming families within each specific sub-group have roughly the same production constraints and development alternatives. This is the concept of “recommendation domain” (RD) which was first introduced by Byerlee *et al.* (1980). They described the RDs as the groups of farmers for whom more or less the same recommendations can be made. In the light of the foregoing arguments, the aim of this paper is to empirically establish that there exists wide diversities in terms of resource base even within the so-called smallholder coconut-based intercropping farmers, and to regroup them into homogeneous groups thus facilitating the application of different development strategies for different groups.

## MATERIALS AND METHODS

### Data

Data were collected from a field survey of 113 farmers adopting coconut-based intercropping systems in three main coconut growing districts in Sri Lanka, namely Gampaha, Kurunegala and Puttalam. Although these districts comprise five agro-ecological regions, namely IL<sub>1</sub>, WL<sub>2</sub>, WL<sub>3</sub>, WL<sub>4</sub> and WM<sub>3</sub>, greater percentage (86%) of Coconut Development Officer (CDO) ranges<sup>2</sup> fall in the IL<sub>1</sub> and WL<sub>3</sub>, and hence only the CDO ranges falling in IL<sub>1</sub> and WL<sub>3</sub> were purposively selected for the survey. The land area of the above three districts falling under IL<sub>1</sub> agro-ecological region is greater than that of the WL<sub>3</sub> and hence about 60 per cent of sampling units (68 farmers) were allocated into IL<sub>1</sub> agro-ecological region while the remaining 40 per cent (45 farmers) were allocated into WL<sub>3</sub>. Sampling units were allocated in each CDO range as follows.

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<sup>2</sup> A CDO is a village level coconut extension officer attached to the Coconut Cultivation Board of Sri Lanka (CCBSL) which is the statutory body involved in transferring research findings of the Coconut Research Institute to coconut growers. A CDO has an official obligation to cater for a particular land area under coconut, which is called a *CDO range*.

Table 1 Distribution of intercroppers in CDO ranges			
Agro-ecological region			
IL <sub>1</sub>		WL <sub>3</sub>	
CDO range	Farmers	CDO range	Farmers
Dummalasuriya	8	Nittambuwa	7
Kuliyapitiya	7	Mirigama	7
Welpalla	7	Pallewela	8
Yackwila	8	Minuwangoda	8
Dambadeniya	7	Urapola	8
Weerambagedara	7	Weke	7
Udubaddawa	8		
Dankotuwa	8		
Hamangalla	8		
Total	68		45

Data were collected through a single visit by personal interviews using a structured schedule.

## Cluster Analysis

- **Definition**

Everitt (1974) defined the cluster analysis as a group of techniques that divide a set of objects into groups so that objects within the same group are “similar” and objects from different groups are “dissimilar”. The theoretical consideration of cluster analysis is outlined below.

### a) Cluster analysis techniques

Techniques for cluster analysis seek to separate a set of data into groups or clusters. These techniques can be classified into five types as follows. However, they are not mutually exclusive and several clustering techniques could be placed in more than one category.

- i) Hierarchical techniques
- ii) Optimization-partitioning techniques
- iii) Density or mode-seeking techniques
- iv) Clumping techniques
- v) Others

A full review of all the above techniques is beyond the scope of this study, and only techniques that seem important are outlined below and the appropriate technique for the present study is chosen.

### ***i) Hierarchical clustering techniques***

Hierarchical techniques can be sub-divided into agglomerative methods and divisive methods. A set of entities are clustered into groups by a series of successive fusions in agglomerative methods, while the divisive methods divide the set of entities into smaller elements by a series of successive partitions. The results of both methods are presented in the form of a dendrogram, a two-dimensional diagram illustrating the fusions or partitions that took place at each successive level. The hierarchical techniques do not clearly indicate the number of groups, but this can be determined by examining the dendrogram for large changes between fusions. The researcher can use his judgment for this purpose.

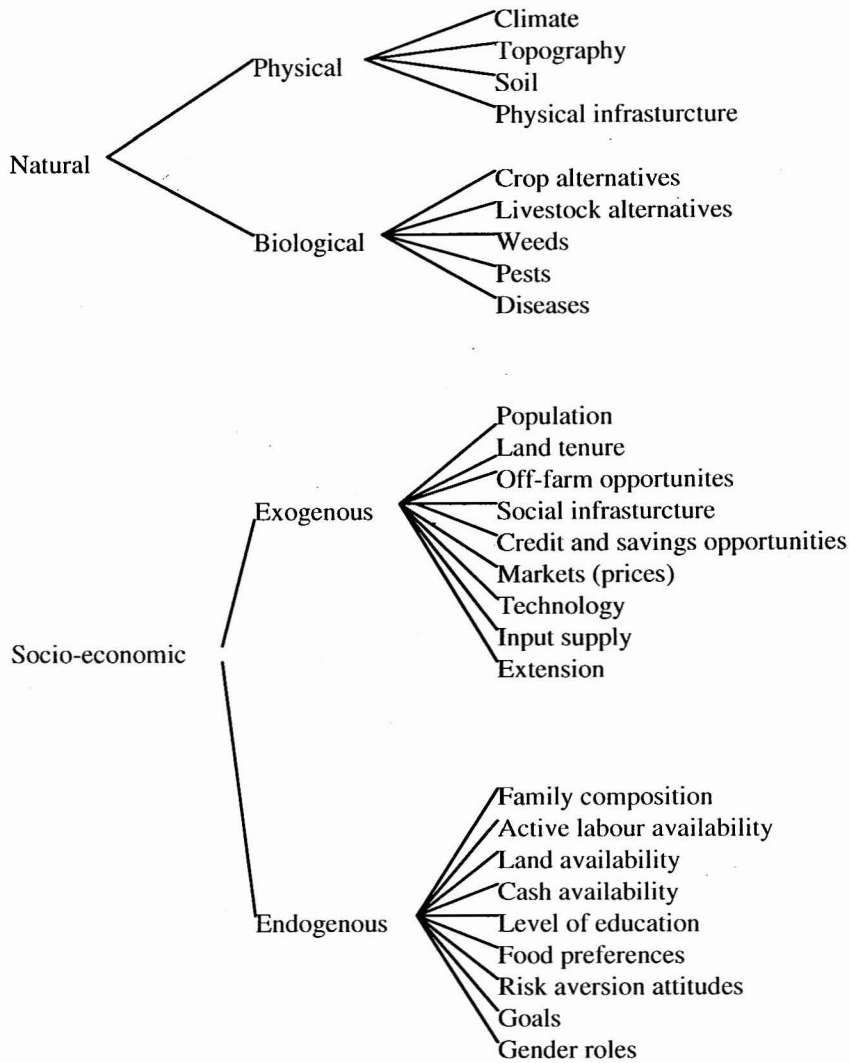
#### ***1 Agglomerative methods***

All the techniques coming under the agglomerative methods (called agglomerative hierarchical techniques) begin with the computation of a similarity or distance matrix between the entities, hence all these methods have a similar procedure. They finally generate a dendrogram, which shows the successive fusions of individuals (coconut intercrops in this case) into bigger and bigger clusters and culminates when all the individuals are in one group. Examples of agglomerative hierarchical methods include single link method, complete linkage method, centroid method, median cluster analysis method, group average method and Ward's method. Ward's method is one of the most frequently used methods and operationally simple in SPSS-PC program. Therefore, this method was used for this study.

A description of the alternative methods that can be used are given in Everitt (1974). Some of these alternative methods are suitable only for small data sets, while others assume the numbers of clusters *a priori*.

### ***b) The choice of variables for the cluster analysis***

The choice of the relevant variables for the cluster analysis is a judgment of the researcher. There are many determinants of a farming system. Individual farms are characterized by the values taken for these determinants and variation in these determinants make each farm unique, and they also influence the adoption of a technology to different degrees. Jolly (1988) has classified these factors as natural and socio-economic (Figure 1).



Source: Jolly, 1988

**Figure 1:** Determinants of a farming system

Exogenous and endogenous variables such as credit, price, inputs and cultural practices that can be easily manipulated by researchers and policy makers were named as "action variables" by Jolly (1988). In this study, only the endogenous variables were used to classify the farmers. Other variables, i.e. exogenous variables were not considered due to measurement difficulties.

There is a range of endogenous variables, which determine a particular farming system. For coconut-based intercropping systems, they would be: family size, annual family labor availability for farm work, annual family labor employed for supervisory work in the farm, income from occupation, income from rice, income from coconut, income from livestock, off-farm income, income from hiring out machinery, wealth, household expenditure, total income, highland area, lowland area, intercropping area, annual working capital availability etc.

A correlation matrix was constructed using the above variables (Appendix Table A1). As suggested by Hardiman *et al.* (1990), variables having the highest correlation coefficients and largest standard of deviations were selected for the cluster analysis. They are: annual family labor availability for farm work, annual family labor employed for supervisory work in the farm, income from occupation, income from rice, coconut income, income from livestock, off-farm income, wealth, household expenditure, total income, highland area, lowland area, intercropping area and annual average cash availability (see Appendix Tables A1 and A2<sup>3</sup>). Ward's method uses the squared Euclidean distance measure. The variables used for the cluster analysis have different units of measurements. Everitt (1974) has pointed out that techniques using Euclidean distance measure may give different solutions on the raw and standardized data because the variables with a large numerical value will be given a relatively large weight when the distance between two objects are calculated. Therefore, the unstandardized data have an effect on the distance measure. Standardization of the variables to zero mean and unit standard deviation overcomes this problem. Hence, the variables were expressed in standardized form (standard score or Z-score), and then the standardized data were used for the cluster analysis. The method of cluster analysis used was Ward's method.

## RESULTS AND DISCUSSION

The selection of variables for the cluster analysis based on the correlation matrix and standard deviation criteria alone has produced disappointing results, because some variables have conflicting interpretative content. It has not produced meaningful clusters (see Appendix Table A3). Consequently, correlation matrix results were supplemented by the authors' subjective judgment to find out the meaningful variables for cluster analysis. The variables finally selected for the cluster analysis were annual family labor availability for farm work, annual family labor for supervisory work, total

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<sup>3</sup> Although the standard deviation of some variables namely family size, lowland ownership and intercropped area were relatively less, they were included for the cluster analysis as they are key variables in CBI systems.

income, off-farm income, highland area, annual household expenditure, cash availability, rice land area, percentage of land under intercropping and annual average rice consumption. Cluster analysis using these variables produced the dendrogram (Appendix Figure A1), and the author subjectively decided on three homogeneous farmer groups<sup>4</sup>. Group I, Group II and Group III included 56, 44 and 12 farmers respectively, representing resource-poor, middle level and affluent farmers respectively. The values of the rescaled distances at which the clusters I, II and III formed were 10.88, 10 and 17.65 respectively. An exceptional farmer was identified with very high resources that do not fit into any of the above three groups and was excluded from further analyses. Table 2 shows the cluster averages of different variables.

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<sup>4</sup> The terms “group” and “cluster” are synonymously used in this paper.

**Table 2** : Averages of selected variables in different farmer groups

Variables	Cluster I (resource- poor farmers)	Cluster II (Middle-level farmers)	Cluster III (Affluent farmers)
• Family labor for farm work (md/year)	295.29	217.39	163.29
• Family labor for supervisory work (md/year)	0	9.72	87.46
• Off farm income (Rs/year)	4 275	30 545	33 000
• Household expenditure (Rs/year)	60 477	92 120	131 269
• Total income (Rs/year).	163 854	322 821	571 672
• Highland area (ac)	3.73	9.90	15.54
• Cash availability (Rs/year) <sup>x</sup> --- (A)	68 969	155 265	239 129
• (A) - (GM from coconut + GM from rice)	47 205	95 077	138 175
• Riceland area (ac)	1.08	1.59	2.02
• % of land under intercroops	48.35	43.00	37.00
• Annual average rice consumption (bushels)	38.37	44.75	32.86

Notes: GM - gross margin.

x - gross margin contributed by intercroops were not included to derive the cash availability.

Source: Farmer survey, 1995.

It can be generally observed that there are significant differences among the three farmer categories with respect to each selected variable. The family labor availability for farm work is the highest in resource poor farmers (cluster I) while it is the lowest in affluent group of farmers (cluster III). Affluent farmers have shown the lowest family labor availability for farm work, so they have to heavily rely on hired labor. Resource-poor farmer group never works in their farms as supervisors although affluent farmers do so. Off-farm income is the highest in affluent farmers because they are part-time farmers having diverse sources of other incomes, while it is the lowest in resource-poor farmers as they heavily rely on farm income for their living. Corresponding relationships, i.e. the highest figure in affluent farmers and the lowest figure in resource-poor farmers can be observed with regard to such variables as household expenditure, total income, highland area, cash availability and rice land area. However, the percentage of intercrops shows the opposite relationship, the highest is in resource-poor farmers and the lowest is in affluent farmers. The reason for this observed relationship is because the highland area owned by resource-poor farmers is considerably low and hence the fraction of land under intercropping tends to be high for these farmers, although perhaps the absolute average under intercropping is greater in affluent group of farmers. In summary, this study empirically established that there is a considerable heterogeneity even among smallholder coconut farms, which are frequently considered as homogenous for technology development and dissemination.

Three different recommendation strategies for the three different farmer groups are therefore necessary.

**Farmer group I:** Labor-intensive technologies such as coconut-based intercropping (CBI) involving annual and semi-perennial intercrops (betel) are appropriate for these farmers because they are full-time farmers with the highest availability of family labor for farm work. They rely mainly on farm income for their living and they are often cash scarce farmers. Cash-intensive technologies having longer pay back periods, e.g. moisture conservation in coconut lands using husks in pits, contour drains etc., are not appropriate to these farmers unless an increased access to low interest loans are ascertained.

**Farmer Group II:** A compromise strategy between the recommendation strategies to group I and group II farmers is required.

**Farmer Group III:** Technologies requiring greater commitment of family labor is undesirable for this group of farmers, as they are part-time farmers heavily involved in off-farm income generating activities. Maintaining of coconuts as a monocrop is ideally match with their circumstance, but land-

augmenting technologies such as CBI is feasible even with this group of farmers by making Farm Managers (who are competent to cope up the management demands of CBI) available for them.

## CONCLUSIONS

Coconut farmers having farms ranging from 2 to 20 acres in Sri Lanka are conventionally regarded as smallholders, and the same policies are effected and the same technology recommendations are made for the entire smallholder sector across the board on the assumption that they are all homogeneous in terms of resources and objectives. Despite apparent similarities, there exist wide diversities in terms of resource availability even within the so-called coconut smallholder category. This study has shown the importance of recognizing the above heterogeneity of seemingly homogenous smallholders, specially when sector development policies are formulated, production technologies are developed and disseminated. The lesson is that one should be wary of recommending blanket policies and technologies considering such a broader group of farmers as smallholders. If it is necessary to make blanket recommendations, the smallholders should be further re-grouped into smaller groups to warrant such recommendations.

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APPENDIX

Table A1 Correlation matrix of the cluster variables

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
B	1															
C	0.1646	1														
D	-0.2005	.3776**	1													
E	0.1779	-0.1956	0.0675	1												
F	0.1607	-0.0509	-0.0111	-0.0753	1											
G	0.1374	-0.0089	-0.007	-0.0461	.6139**	1										
H	0.1053	-0.0059	-0.0293	0.2107	-0.0879	-0.0635	1									
I	0.0614	-0.1004	-0.0219	0.1807	.2562*	.3001**	0.0064	1								
J	-0.0782	0.0296	0.0208	-0.113	0.0052	-0.0656	-0.0682	0.0498	1							
K	-0.1428	-.2280*	.4548**	0.0042	0.2006	.3915**	-0.0101	0.048	-	1						
L	0.2276*	-0.1324	0.0532	.2445*	0.0426	0.196	0.0315	.2448*	0.0284	0.0642	1					
M	0.1685	0.1387	-0.0238	0.0338	.3226**	.5805**	.2881**	.3545*	0.1936	0.1835	.3839*	1				
N	-0.1256	-0.2061	.2460*	-0.0861	.3884**	.7119**	-0.0394	.2948*	0.0435	.5516**	.3315*	.4543**	1			
O	0.1263	-0.0589	0.0385	-0.0314	.8303**	.6154**	-0.075	.2989*	-	.2432*	0.0628	.3596**	.4654**	1		
P	0.0277	-0.0111	0.12	-0.1345	.2671*	.4860**	-0.0457	.4832*	0.0038	0.2007	.2628*	.5986**	.5510**	.4031**	1	
R	0.2329*	-0.1043	-0.0184	.3075**	.5316**	.7228**	.2581*	.5923*	0.0905	.2360*	.3699*	.6515**	.4917**	.5497**	.5031*	1

Notes: \* - One tailed significance 0.01, \*\* - One tailed significance 0.001, Number of observations 113.

B - Family size.

C - Annual family labor for farm work.

D - Annual family labor involved in supervisory work.

E - Annual income from occupation.

F - Annual income from rice.

G - Annual income from coconut.

H - Annual income from livestock.

I - Annual income from non-farm sources.

J - Annual income from hiring out of machinery.

K - Wealth.

Source: Farmer survey, 1995.

L - Annual household expenditure.

M - Annual total income.

N - Highland ownership.

O - Lowland ownership.

P - Inter cropped area.

R - Annual working capital availability.

**Table A2:** Standard deviations of cluster variables

Variable	Standard deviation
B	1.19
C	170.10
D	47.34
E	51207.65
F	24069.78
G	87963.43
H	72956.12
I	54305.47
J	27121.50
K	3397505.71
L	49285.05
M	230122.27
N	6.84
O	1.68
P	3.55
R	116825.63

Notes:

B - Family size.

C - Annual family labor for farm work.

D - Annual family labor involved in supervisory work.

E - Annual income from occupation.

F - Annual income from rice.

G - Annual income from coconut.

H - Annual income from livestock.

I - Annual income from non-farm sources.

Source: Farmer survey.

J - Annual income from hiring out machinery.

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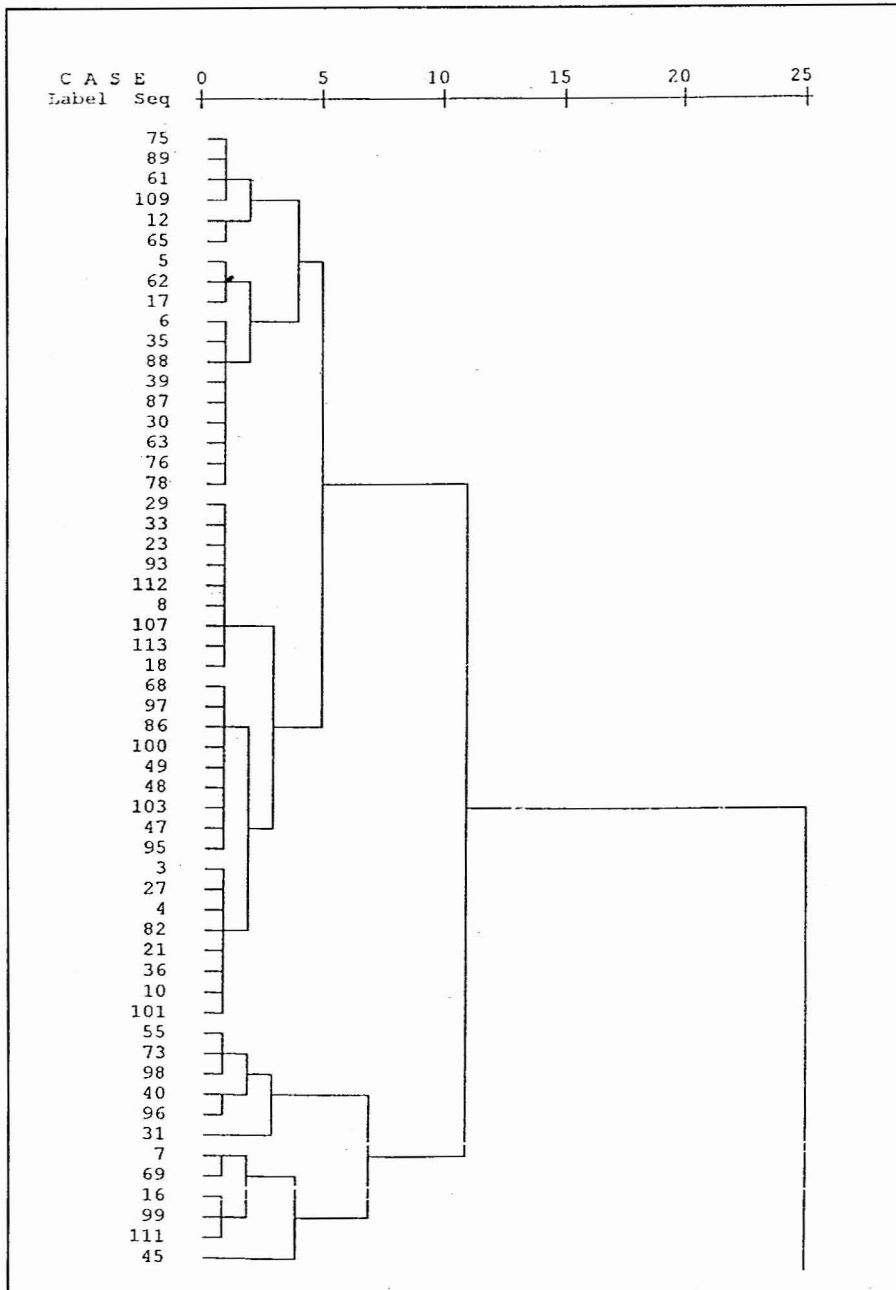
P - Intercropped area.

R - Annual working capital availability.

**Table A3:** Cluster averages of variables

Variables	Clusters				
	I (38)	II (66)	III (4)	IV (2)	V (3)
• Family labor availability for farm work (md/year)	333	211	0	228	418
• Family labor availability for supervisory work (md/year)	0	8.48	229	0	0
• Income from occupation (Rs/year)	28335	46362	50250	121800	28000
• Income from rice (Rs/year)	7926	22121	24075	9600	93507
• Income from coconuts (Rs/year)	26867	64631	66931	29433	484710
• Income from livestock (Rs/year)	9018	4305	0	533000	0
• Off-farm income (Rs/year)	4247	26818	0	24000	133333
• Wealth (Rs)	1168235	2899291	1021785	3078167	6360163
• Household expenditure (Rs/year)	51566	97183	59295	99520	111695
• Total income (Rs/year)	137642	310334	224181	809433	1056970
• Highland area (acres)	3.83	8.63	17	7	23.25
• Lowland area (acres)	0.5	1.74	2.5	0.875	6.67
• Intercropped area (acres)	1.66	3.12	4.5	2.88	13.42
• Cash availability (Rs/year), excluding: a) the GM from intercroops, and b) household expenditure	62246	138708	94594	372853	599625

Notes - Values in parentheses are the number of farmers, md - man days, GM - gross margin.  
Source: Farmer survey, 1995.



**Appendix Figure A 1:** Dendrogram showing successive fusion of coconut-based intercrops

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