Management of Coffee Leaf Rust Disease in India: Evidence for Socio-economic and Locational Determinants

M.R. Narayana
Institute for Social and Economic Change, India
Email: mrnarayana@yahoo.com; mrn@isec.ac.in

ABSTRACT

Coffee leaf rust is a major disease affecting the production of Arabica coffee. This paper presents an estimation of socioeconomic and locational determinants of CLR management as they relate to the application of fungicides (Bordeaux mixture and systemic fungicides) in India. Using survey data from 575 growers (comprising 90% small and poor growers), estimates of binary logit models offer evidence on the significant impact of altitude, rainfall, age of household head, economic status, social caste, and size of bearing area of the Arabica coffee cultivation on CLR management. Given the socioeconomic and estate variables, the estimated probability of adoption is highest for Bordeaux mixture. These results offer new insights into CLR management practices beyond the known cultural and cultivation practices. They imply a need for public policy on recommended CLR management practices and subsidy for chemical inputs to improve production and productivity of small and poor Arabica coffee growers. Further, the framework and results are relevant and applicable to other Arabica coffee growing countries in Asia and Africa.

Keywords*:* coffee leaf rust, Arabica coffee, Bordeaux mixture, systemic fungicides, binary logit model
JEL classification*:* Q16, Q13, Q19

INTRODUCTION

Coffee is an important plantation crop with economic significance in India. Its cultivation activities generate income, employment, and output in the agricultural sector. Coffee output is used for intermediate and final domestic consumption and export. For instance, it is used as input or intermediate consumption in coffee-related agri-food processing industries in the manufacturing sector. Domestic wholesale and retail marketing of coffee is an important activity in the services sector. Thus, the coffee sector contributes to the gross domestic product (gross state domestic product) in the primary, secondary and tertiary sectors, and ultimately to the national (regional/state level) economic growth.

Coffee leaf rust (CLR) is an important disease affecting coffee production. According to the Coffee Board (2009a), when the disease is severe, loss of foliage up to 50 percent and berries up to 70 percent can occur. Uncontrolled CLR, among other factors, has a negative impact on coffee production, especially Arabica coffee, which is more susceptible to CLR than Robusta.

CLR[1] management refers to all coffee farming practices that are directly or indirectly aimed at preventing the occurrence and spread of the disease in order to increase coffee production and productivity. The management or cultural practices include chemical sprays, intercropping, weeding, pruning, shade regulation, topping, de-suckering, and application of fertilizers/nutrients. In addition, cultivation of CLR-resistant coffee varieties is an important measure to manage CLR. In general, Indian coffee farmers in all regions adopt these practices. A notable exception is chemical sprays in the form of fungicides (Bordeaux mixture and systemic fungicides, particularly Bayleton® and Contaf®), which are uniquely region-specific. This uniqueness is seen in the number of fungicide adopters or non-adopters in traditional coffee-growing regions in India. What may explain this uniqueness beyond the known cultural and cultivation practices of CLR management? This paper attempts to answer this relevant policy question using descriptions and estimations of socioeconomic and locational determinants of fungicide adoption and non-adoption in India.[2]

To the researcher's knowledge, no study exists in or outside India on the nature and extent of impact of socioeconomic and locational variables on farmers' adoption of CLR management practices. This research gap is evident, for instance, in Indian studies on cost of coffee cultivation (Reddy, Shivprased, and Naidu 2003; Reddy 2004; NABARD 2011); and international studies on CLR impact (Schieber 1972) and management (Hillocks, Phiri, and Overfield 1999; Phiri, Hillocks, and Jeffries 2001; Avelino et al. 2006). Thus, this paper hopes to contribute to the understanding of socioeconomic and locational determinants of CLR management, and draws implications on Arabica coffee growing in India, which may be relevant and applicable to other countries in Asia and Africa as well.

The main objectives of this paper are to estimate the socioeconomic and locational determinants of adoption or non-adoption of CLR management practices by types of fungicide and their schedule of spraying. Socioeconomic factors include social caste, economic status, educational background, and size of estate. Locational factors include estate profile variables like slope, altitude, aspect, and rainfall. All estimations are based on bivariate logit model, using newly collected household-level data from 575 sample growers (largely comprising poor and small growers) of Arabica coffee from India's traditional coffee-growing states: Karnataka, Kerala, and Tamil Nadu. Analysis of estimation results were expected to provide strong empirical justifications for inclusions of factors that are specific to the socioeconomic background of growers and/or locational features of coffee estates, for promotion of CLR management practices through policy interventions.

The main results show that the fungicide adopters (or non-adopters) are uniquely distinguishable by coffee region, socioeconomic factor, and estate profile. Logit model estimates offer evidence on the significant impact of socioeconomic and estate profile variables on the probability of fungicide adoption for CLR management. The important variables include altitude, rainfall, age of household head, economic status, social caste, and size of

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1 Scientific details of CLR are available in Coffee Board (2009a). These details include symptoms, favorable factors for spread of disease; disease development phases; and period of extension, intensification, defoliation, and inactivity. This source also provides technical details of CLR management.

2 This approach assumes that all other CLR management practices are uniformly followed by all growers. This assumption is generally supported by evidence from this study's sample survey of 575 growers.

bearing area of the Arabica coffee cultivation. Given the socioeconomic variables and estate profiles, the highest adoption probability is evident for Bordeaux mixture.

These empirical results justify the inclusion of socioeconomic and location-specific variables in designing a policy that promotes adoption of CLR management practices. Such a policy may have important implications on sustainable income generation and long-term livelihood security of farmers, especially in view of their small production size and scale. Subject to the comparability of socioeconomic structures of farmers and locational factors in farming, the results and implications of the study may also be relevant to CLR-affected coffee-growing countries in Asia and Africa.

The rest of the paper is organized as follows. The second section describes a new database used for measurement and estimation of relationships between the variables and an overview of CLR management practices. The third section discusses the socioeconomic characteristics and estate profiles of adopters and non-adopters. The fourth section presents a framework for empirical estimation and variables' descriptions. The fifth section discusses the estimation results. The last section presents the conclusion and implications.

DATABASE

The management of CLR is an individual or household grower decision. In this regard, a nationally representative and disaggregated database on household growers is essential to measure variables in the estimation of socioeconomic determinants of adoption or non-adoption of CLR management practices. In the absence of such a database in India, a new database was created to accomplish the objectives of this paper.

Creation of a New Database on Household Growers

Primary data were collected from a sample of 575 coffee growers representing all the traditional Arabica coffee-growing states/regions in India, from 23 February to 31 August 2010.[3] The traditional coffee-growing states/regions are Karnataka, Kerala, and Tamil Nadu. These regions accounted for about 98 percent of total coffee production (94% of total Arabica production) by post-monsoon and post-blossom estimates in 2010–11. Karnataka, in particular, is the largest producer among the three regions. Its three major coffee-growing districts—Chikmagalur (about 40%), Kodagu (about 22%), and Hassan (about 18%) accounted for about 80 percent of total coffee production. The other coffee-growing districts are Pulneys, Shevroys, and Annamalais in Tamil Nadu and Nelliampathis in Kerala.

The household is the unit of analysis. The sample was selected based on multi-stage and simple random sampling method. The multi-stage sample design had three stages. In stage I, the total sample was allocated according to the three states' share in terms of the following five variables in Arabica coffee production: (a) planted area in 2007–08, (b) planted area in 2008–09, (c) coffee production in 2007–08, (d) coffee production in 2008-09, and (e) coffee production in 2009–10.[4] These allocation criteria provided flexibility in choosing a range of actual sample sizes, depending on the fieldwork conditions. In stage II, the sample size in stage I was allocated according to the distribution of growers by estate size of Arabica

3 This survey was part of a larger study conducted by the author on Socioeconomic Analysis of Increasing Resilience of Coffee Production to Leaf Rust Disease.

4 Basic data on planted area and coffee production were from Coffee Board (2011).

coffee planted area in each state. The objective was to sufficiently represent the small growers. In stage III, the final sample of growers was drawn from all the liaison zones of the Coffee Board of India. In the absence of a complete household listing of coffee growers, the entire fieldwork was implemented with the guidance of the officials and staff in the extension services of the Coffee Board. A structured questionnaire was used to collect primary data on coffee production, CLR incidence, CLR control methods, and cost of coffee cultivation with special reference to CLR management. Trained investigators directly interviewed the growers at their estates.

The 575 sample growers were distributed as follows: 73 percent (417 growers) from Karnataka, 18 percent (103 growers) from Tamil Nadu, and 9 percent (54 growers) from Kerala. Of the 417 sample growers from Karnataka, 44 percent were from Chikmagalur, 31 percent from Kodagu, and 25 percent from Hassan.

Small growers (having less than 10 hectares (ha) or less than 25 acres) constituted the highest share of sample growers at the national, state, and district levels. They composed 90 percent at the all India level. Within Karnataka, the share of small growers was about 86 percent in Chikmagalur, 94 percent in Hassan, and 94 percent in Kodagu. In particular, the smallest growers (having less than 2 ha or 5 acres) and smaller growers (having less than 4 ha or 10 acres) accounted for 51 and 21 percent, respectively, of the national sample; at the state/region level, it was 43 and 24 percent in Karnataka, 81 and 7 percent in Kerala, 64 and 14 percent in Tamil Nadu, respectively. Thus, the results of this paper are particularly relevant to these vulnerable groups of coffee growers.

An Overview of Current Cultural and Cultivation Practices in CLR Management

Several current cultural practices under bush management—application of chemical fertilizers and farm yard manure and chemical sprays—contribute to effective CLR control and management. Table 1 lists these practices by proportion of adopters. The widely practiced methods included intercropping, pruning, fertilizer application, shade regulation, topping, and de-suckering. The application of chemical fertilizers and farm yard manure and chemical sprays was also widely practiced in all states and districts. Terracing was the least practiced method; less than 10 percent of the farmers in all the states and districts practiced it. In general, these practices were higher in Karnataka than in other states; among Karnataka's districts, they were highest in Hassan.

Chemical sprays are important methods of CLR management. These sprays use the Bordeaux mixture and systemic fungicides (i.e., Bayleton and Contaf). It is quite noteworthy that about 97 percent of growers in Karnataka used this method, whereas it is only about 19 percent in Kerala and 36 percent in Tamil Nadu. The variety of coffee grown also has important implications on CLR management (Coffee Board 2009b). About 72 percent of sample growers in Karnataka cultivated CLR-tolerant varieties (e.g., S.795), compared with only about 22 percent in Kerala and 57 percent in Tamil Nadu. The most CLR-resistant varieties grown in Kerala and Tamil Nadu included Selection 9 and Cauvery. Karnataka's Kodagu District had the largest number of growers of CLR-resistant varieties (68% used Selection.6) and CLR-tolerant varieties (60% used S.795). In principle, growers of CLR-resistant varieties (e.g., Kerala and Tamil Nadu) had a lower demand for CLR management practices.

Table 1 also shows that among the varieties, Chandragiri was cultivated by the least number of farmers across regions. This may be due to two reasons (Coffee Board 2009b): the variety was released in 2007 only, and it is suitable for high altitudes (1,015.65 meters (m) and above). Given that coffee cultivation in India is mostly found below 1,067.50 m, it is not surprising to find low adoption of Chandragiri (Table 1).

CLR MANAGEMENT PRACTICES BY CHEMICAL SPRAYS

This section presents the descriptions and estimations of the determinants of adoption or non-adoption of chemical sprays as a strategy for management of CLR in India, using the survey data from 575 sample household growers. It discusses the socioeconomic and estate profile factors (other than coffee varieties grown) affecting variability in chemical spray application across farmers.

Adopters and Non-adopters

The recommended dosages and input combinations of the chemical sprays are as follows: (1) Bordeaux mixture (1kg copper sulphate + 1 kg lime at 0.5%) for 5 barrels/acre[5] per spray; (2) systemic fungicides (Bayleton at 160 g/barrel or Contaf at 400 ml/barrel) for 3 barrels/acre per spray. The recommended total of 5 spray schedules and 9 fungicide combinations are (1) two rounds of Bordeaux mixture, (2) two rounds of systemic fungicides (Contaf or Bayleton), (3) three rounds of systemic fungicides, (4) two rounds of systemic fungicides and one round of Bordeaux mixture, and (5) one round of Bordeaux mixture and one round of systemic fungicides. Recommended CLR management practices refer to those espoused by the Coffee Board (2009a). Based on current practices, adopters of the recommended practices used the following: two-rounds of Bordeaux mixture, two-rounds of systemic fungicides, and one round of Bordeaux mixture and two rounds of systemic fungicides. Non-adopters, on the other hand, used the following: one round of Bordeaux mixture, one round of systemic fungicides, and two rounds of Bordeaux mixture and one round of systemic fungicides. Adopters are classified into two groups: those who use either the Bordeaux mixture or systemic fungicide (BM/SF) or those who use a combination of the Bordeaux mixture and systemic fungicide (BM&SF).

A distinct distribution pattern of adopters of CLR management practices is evident in the coffee growing states and districts in Karnataka (Table 2). Adopters are higher than non-adopters in all states and districts, regardless of practices. Moreover, adopters of BM/SF are higher than the adopters of BM&SF. Karnataka had the highest share of adopters regardless of practices while Tamil Nadu had the least. For instance, of the total adopters (369 growers), about 97 percent are in Karnataka while only 0.5 percent are in Kerala and 2 percent in Tamil Nadu. Among the coffee growing districts within Karnataka, Chikmagalur has the most adopters (about 46%). Interestingly, Kodagu has a relatively higher number of adopters (about 34%) of BM/SF than Hassan (about 21% only). On the other hand, Hassan has relatively more adopters (about 36%) of BM&SF than Kodagu (about 18%).

In terms of non-adopters, the highest share is evident in Tamil Nadu (about 46%) and Kodagu (about 54%). These observations are consistent with the pattern of coffee varieties grown in these states (i.e., CLR-tolerant

5 One barrel is equal to about 117.348 litres and one acre is equal to about 0.405 hectare.

Table 1. Current cultural and cultivation practices of CLR management by household growers in India's traditional coffee growing regions

Practices of CLR Management	Karnataka				Kerala (*N*=54)	Tamil Nadu (*N*=104)	Total (*N*=575)
	Chikmagalur (*N*=185)	Hassan (*N*=104)	Kodagu (*N*=128)	Total (*N*=417)			
Current cultural practices							
Mulching	55.14	63.46	50.78	55.88	40.74	19.23	47.83
Terracing	10.81	0.96	3.13	6.00	5.56	1.92	5.22
Intercropping	93.51	97.12	96.88	95.44	96.30	86.54	92.87
Slashing	60.00	65.38	57.81	60.67	59.26	33.65	55.65
Pruning	98.38	100.00	99.22	99.04	92.59	96.15	97.91
Fertilizer	100.00	100.00	99.22	99.04	50.00	77.88	90.61
Farm yard manure	84.86	87.50	86.72	86.09	100.00	64.42	83.48
Chemical spray	98.92	99.04	93.75	97.36	18.52	35.58	78.78
Shade regulation	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Topping	96.22	100.00	97.66	97.60	100.00	100.00	98.26
De-suckering	90.81	100.00	93.75	94.00	100.00	100.00	95.65
Cultivation practices (variety of Arabica coffee grown)							
S.795	84.32	66.35	60.16	72.42	29.63	58.65	65.91
Selection.5B	4.32	2.88	0.78	2.88	0.00	14.42	4.35
Selection.6	34.05	53.85	67.97	49.4	0.00	0.00	35.83
Selection.9	52.97	25.00	50.00	45.08	87.04	79.81	55.65
Cauvery	27.57	34.62	18.75	26.62	16.67	19.23	23.65
Chandragiri	3.24	6.73	0.78	3.36	5.56	5.77	4.00

Notes: All figures are percent to total sample size in each state and by each indicator.
N refers to total number of sample farmers.

Table 2. Distribution by adopters and non-adopters of CLR management practices

	Adopters			Total Non-adopters
	BM/SF	BM&SF	Total Adopters	
States	96.82	97.32	97.02	28.64
Karnataka	0.45	0.67	0.54	25.24
Kerala	2.73	2.01	2.44	46.12
Tamil Nadu	220	149	369	206
Total	213	145	358	59
Districts in Karnataka	0.45	0.67	0.54	25.24
Chikmagalur	45.07	46.21	45.53	25.42
Hassan	21.13	35.86	27.09	20.34
Kodagu	33.80	17.93	27.37	54.24
Total-Karnataka	100.00 (213)	100.00 (145)	100.00 (358)	100.00 (59)

Note: Figures in parentheses refer to total sample size

varieties in Karnataka and CLR-resistant varieties in Kerala and Tamil Nadu).

The adoption pattern within the coffee growing states is more remarkable (Table 3). Of the total sample growers in Karnataka, about 86 percent are adopters: 51 percent of BM/SF and 35 percent, of BM&SF. In contrast, non-adopters are highest in Kerala (about 96%) and Tamil Nadu (about 91%). Among the districts in Karnataka, the share of adopters in the total sample of growers is 92 percent in Chikmagalur, 90 percent in Hassan, and 75 percent in Kodagu. There are more adopters of BM/SF in Chikmagalur while there are more adopters of BM&SF in Kodagu.

Overall, the above results indicate that the determinants of adoption of CLR management strategies are particularly relevant for growers in Karnataka (and non-adoption in Kerala and Tamil Nadu).

Socioeconomic Characteristics of Adopters and Non-Adopters

Are there remarkable socioeconomic characteristics to distinguish between the adopters and non-adopters of CLR management practices? This question is answered in this section by cross tabulating the adopters of BM/SF and those of BM&SF by selected non-price socioeconomic characteristics of farmers.

Table 4 shows the cross tabulation of adopters by six socioeconomic characteristics of growers in Karnataka by districts. The results show considerable variations among the characteristics across regions and CLR practices, as follows:

- Adopters are mostly in two age groups: 25–50 years and 50–75 years.
- Households with male heads are highly responsive to the adoption.
- All social categories of growers are generally responsive to adopting the CLR management practices. In particular, growers belonging to the general social category are more responsive than growers belonging to the scheduled caste (SC), scheduled tribe (ST), and other backward classes (OBCs).[6]
- Growers with no education to high school education are the largest adopters. This implies that secondary and post-secondary education may not be a precondition for technology adoption.
- Relative economic status of growers is identified by possession of a ration card—that is below poverty line (BPL) card holders and above poverty line (APL) card holders. These card holders are eligible to receive the select foodgrains at subsidized prices. The figures show that better economic status does influence adoption because APL card holders are more responsive to adopting the practices than BPL cards holders.[7] Except

6 There are no income or poverty scale for social categorization of people by scheduled caste (SC), scheduled tribe (ST), and other backward classes (OBC). In fact, the categorization is based on social caste or community in which the individuals are born or converted. In general, individuals belonging to these categories are identified by their lower social, economic, and educational status. The categories are provided, among others, with reservations in jobs and admission to educational institutions in government and public/aided institutions. At present, the extent of reservation is 15 percent for SC, 7.5 percent for ST, and 22 percent for OBCs. The reservation policy is an affirmative action and constitutionally provided and guaranteed. The constitutional provisions and welfare schemes for SC and OBC are available on the website of the Ministry of Social Justice, Government of India http://socialjustice.nic.in/ (accessed on 01 July 2013).

7 For instance, under the Targeted Public Distribution System (Government of Karnataka 2011), the following commodity entitlements are distributed monthly for the BPL (or APL) card holders in Karnataka State: (a) 4 kg of rice per person, subject to a maximum of 20 kg, at the rate of INR 3/kg (or 5–15 kg at INR 9.40); (b) 1 kg of wheat per person, subject to a maximum of 3 kg, at the rate of INR 3/kg (or 1–4 kg at INR 7.20); and (c) 1 kg of sugar at INR 13.50/kg.

Table 3. Distribution of farmers by adopters and non-adopters of CLR management practices within the states and districts

	Adopters			Total Non-adopters	Total Adopters and Non-adopters
	BM/SF	BM&SF	Total Adopters		
States					
Karnataka	51.08	34.77	85.85	14.15	100.00 (417)
Kerala	1.85	1.85	3.70	96.30	100.00 (54)
Tamil Nadu	5.77	2.88	8.65	91.35	100.00 (104)
Total	38.26	25.91	64.17	35.83	100.00 (575)
Districts in Karnataka					
Chikmagalur	53.93	37.64	91.57	8.43	100.00 (185)
Hassan	41.28	47.71	88.99	11.01	100.00 (104)
Kodagu	55.38	20.00	75.38	24.62	100.00 (128)

Note: Figures in parentheses refer to total number of sample farmers.

in Chikmagalur and Hassan districts, growers included non-card holders because the combined APL and BPL card holders is less than 100 percent.

- Small growers (having less than 10 ha or about 25 acres) constitute the highest share of growers at the state and district levels. In particular, the smallest growers (with less than 5 acres or 2 ha of estate size) and smaller growers (with less than 10 acres or 4 ha) dominate the sample. Thus, the outcome of the analysis of CLR management is of special relevance to these vulnerable groups of coffee growers in India.

Table 5 shows the cross tabulation of non-adopters in Karnataka, Kerala, and Tamil Nadu by more than six socioeconomic characteristics. Qualitatively, the distribution of non-adopters by these characteristics is comparable, with a few exceptions, with the characteristics of adopters in Table 4. First, a remarkable number of growers with higher or post-secondary education are non-adopters. Second, all the non-adopters are holders of either APL or BPL cards. Third, Chikmagalur district has the largest number of non-adopters (17.64%) who are medium and large growers (estate size of more than 25 acres).

Estate Profiles of Adopters and Non-adopters

Slope, altitude, rainfall, and aspect are the four basic indicators used to describe the estate profile or locational factors that influence CLR occurrence and spread, hence, relevant as regards adoption and non-adoption of CLR management practices.

Table 6 and Table 7, respectively, present the cross tabulation results of adopters and non-adopters by their estate profiles. A few similarities and differences between adopters and non-adopters were noted. In terms of similarities, most adopters and non-adopters are in estates with medium slope and annual rainfall of more than 50 inches but less than 100 inches. In terms of difference, more adopters are in estates at altitudes of more than 3,000 to 3,500 ft, except in Kodagu district, while more non-adopters are in estates at altitudes of more than 3,500 ft, which is not surprising because coffee grown in higher altitudes is less susceptible to CLR. Moreover, most adopters are in estates with eastern and northern aspects, while non-adopters are estates with southern aspects, especially in Kerala and Tamil Nadu.

Table 4. Socioeconomic characteristics of adopters of fungicides for CLR management in traditional coffee growing regions of Karnataka

Socio-economic background characteristics	Adopters of BM/SF				Adopters of BM&SF			
	Chikmagalur (*N*=96)	Hassan (*N*=45)	Kodagu (*N*=72)	Total (*N*=213)	Chikmagalur (*N*=67)	Hassan (*N*=52)	Kodagu (*N*=26)	Total (*N*=145)
Age of household head								
>25 years – ≤50 years	63.54	42.22	44.44	52.58	52.24	44.23	34.62	46.21
>50 years – ≤75 years	34.38	57.78	55.56	46.48	43.28	53.85	61.54	50.34
>75 years	2.08	0.00	0.00	0.94	4.48	1.92	3.85	3.45
Number of male-headed households	95.83	97.78	97.22	96.71	92.54	96.15	96.15	94.48
Social caste								
Belongs to SC or ST	11.46	8.89	1.39	7.51	5.97	5.77	0.00	4.83
Belongs to OBCs	15.63	11.11	6.94	11.74	14.93	25.00	23.08	20.00
Belongs to minority	14.58	17.78	4.17	11.74	4.48	1.92	7.69	4.14
Belong to general category	58.33	62.22	87.50	69.01	74.63	67.31	69.23	71.03
Highest education completed								
Non-formal education (e.g., adult education)	8.33	17.78	4.17	8.92	4.48	15.38	0.00	7.59
Primary school education	6.25	11.11	15.28	10.33	8.96	11.54	7.69	9.66
Upper primary or middle school education	28.13	13.33	12.50	19.72	14.93	13.46	19.23	15.17
High school education	32.29	28.89	29.17	30.52	38.81	28.85	23.08	32.41
Higher secondary or pre-university education	6.25	8.89	13.89	9.39	8.96	19.23	19.23	14.48
Graduate in non-professional education	14.58	20.00	15.28	15.96	19.40	11.54	26.92	17.93
Others	4.17	0	9.72	5.17	2.98	0	0	1.38
Economic status								
Holder of ration card (APL+BPL)	100.00	100.00	93.06	97.65	98.51	98.08	96.15	97.93
Holder to APL card	78.13	77.78	72.22	76.06	83.58	84.62	80.77	83.45
Holder of BPL card	21.88	22.22	20.83	21.60	14.93	13.46	15.38	14.48
Total size of estate or land owned								
<5 acres (2 ha)	58.33	55.56	48.61	54.46	31.34	42.31	34.62	35.86
>5 acres (2 ha) – ≤10 acres	15.63	13.33	23.61	17.84	38.81	25.00	34.62	33.10
>10 acres (4 ha) – ≤15 acres (6 ha)	9.38	15.56	9.72	10.80	11.94	15.38	3.85	11.72
>15 acres (6 ha) – ≤20 acres (8 ha)	5.21	6.67	6.94	6.10	2.99	5.77	7.69	4.83
>20 acres (8 ha) – ≤25 acres (10 ha)	1.04	6.67	8.33	4.69	2.99	1.92	3.85	2.76
>25 acres (10 ha)	10.42	2.22	2.78	6.11	11.94	9.61	15.39	11.73

Notes: All figures are percent to total sample size in each state and by each indicator. All background characteristics refer to the head of household. Non-professional education refers to engineering, medicine, legal, management and agricultural education. N refers to total number of sample farmers.

Table 5. Socioeconomic characteristics of non-adopters of fungicides for CLR management in traditional coffee growing regions of India

	Karnataka (*N*=59)	Kerala (*N*=52)	Tamil Nadu (*N*=95)	Total (*N*=206)
Age of household head				
>25 years – ≤50 years	23.53	47.73	67.16	54.69
>50 years – ≤75 years	70.59	52.27	32.84	44.53
>75 years	5.88	0.00	0.00	0.78
Number of male headed households	88.24	95.45	95.52	94.53
Social caste				
Belongs to SC or ST	0.00	20.45	46.27	31.25
Belongs to OBC	17.65	47.73	50.75	45.31
Belongs to minority	5.88	15.91	2.99	7.81
Belongs to general category	76.47	15.91	0.00	15.63
Highest education completed				
Non-formal (e.g., adult education)	5.88	2.27	17.91	10.94
Primary school	0.00	11.36	8.96	8.59
Upper primary or middle school	17.65	20.45	11.94	15.63
High school	23.53	43.18	28.36	32.81
Higher secondary or pre-university	17.65	13.64	17.91	16.41
Graduate in non-professional	23.53	6.82	11.94	11.72
Others	11.76	2.27	2.99	3.9
Economic status				
Holder of ration card (APL+BPL)	100.00	100.00	100.00	100.00
Holder to APL card	76.47	54.55	35.82	47.66
Holder of BPL card	23.53	45.45	64.18	52.34
Total size of estate or land owned				
<5 acres (2 ha)	23.53	88.64	73.13	71.88
>5 acres (2 ha) – ≤10 acres (4 ha)	23.53	6.82	10.45	10.94
>10 acres (4 ha) – ≤15 acres (16 ha)	17.65	2.27	5.97	6.25
>15 acres (6 ha) – ≤20 acres (8 ha)	11.76	0.00	5.97	4.69
>20 acres (8 ha) – ≤25 acres (10 ha)	5.88	0.00	1.49	1.56
>25 acres (10 ha)	17.64	2.27	1.49	3.9

Notes: All figures are percent to total sample size in each state and by each indicator. All background characteristics refer to head of household. Non-professional education refers to engineering, medicine, legal, management and agricultural education. N refers to total number of sample farmers.

Table 6. Estate profile of adopters of fungicides for CLR management in traditional coffee growing regions ofw Karnataka

Socio–economic Background Characteristics	Adopters of BM/SF				Adopters of BM&SF			
	Chikmagalur (*N*=96)	Hassan (*N*=45)	Kodagu (*N*=72)	Total (*N*=213)	Chikmagalur (*N*=67)	Hassan (*N*=52)	Kodagu (*N*=26)	Total (*N*=145)
Slope								
Very steep	1.04	0.00	0.00	0.47	1.49	0.00	0.00	0.69
Steep	18.75	0.00	4.17	9.86	22.39	0.00	3.85	11.03
Medium slope	59.38	55.56	76.39	64.32	59.70	67.31	88.46	67.59
Gentle slope	13.54	37.78	18.06	20.19	13.43	30.77	7.69	18.62
Plain	7.29	6.67	1.39	5.16	2.99	1.92	0.00	2.07
Altitude (feet)								
≤3,500	34.38	48.89	43.06	40.38	50.75	44.23	42.31	0.00
>3,000 – ≤3,500	45.83	46.67	41.67	44.60	40.30	51.92	34.62	46.90
>3,500 – ≤4,000	19.79	4.44	15.28	15.02	8.96	3.85	23.08	43.45
>4,000 – ≤4,500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.66
>4,500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Annual rainfall (inches)								
≤50	0.00	0.00	6.94	2.35	0.00	0.00	3.85	0.69
>50 – ≤100	87.50	100.00	93.06	92.02	86.57	100.00	92.31	92.41
>100 – ≤150	12.50	0.00	0.00	5.63	13.43	0.00	3.85	6.90
>150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aspect								
Western	21.88	20.00	8.33	16.90	16.42	13.46	3.85	13.10
Eastern	44.79	24.44	45.83	40.85	49.25	44.23	46.15	46.90
Northern	26.04	31.11	37.50	30.99	25.37	36.54	34.62	31.03
Southern	7.29	24.44	8.33	11.27	8.96	5.77	15.38	8.97

Notes: All figures are percent to total sample size in each state and by each indicator.

N refers to total number of sample farmers.

Table 7. Estate profile by non-adopters of CLR management practices in traditional coffee growing regions of India

	Karnataka (*N*=59)	Kerala (*N*=52)	Tamil Nadu (*N*=95)	Total (*N*=206)
Slope				
Very steep	0.00	0.00	2.99	1.56
Steep	0.00	4.55	16.42	10.16
Medium slope	47.06	86.36	71.64	73.44
Gentle slope	52.94	9.09	8.96	14.84
Plain	0.00	0.00	0.00	0.00
Altitude (feet)				
≤3,500	64.71	4.55	1.49	10.94
>3,000 – ≤3,500	35.29	6.82	11.94	13.28
>3,500 – but ≤4,000	0.00	18.18	47.76	31.25
>4,000 – ≤4,500	0.00	70.45	23.88	36.72
>4,500	0.00	0.00	14.93	7.81
Annual rainfall (inches)				
≤50	0.00	0.00	67.16	35.16
>50 – ≤100	100.00	100.00	32.84	64.84
>100 – ≤150	0.00	0.00	0.00	0.00
>150	0.00	0.00	0.00	0.00
Aspect				
Western	5.88	6.82	19.40	13.28
Eastern	64.71	50.00	32.84	42.97
Northern	17.65	27.27	10.45	17.19
Southern	11.76	15.91	37.31	26.56

Notes: All figures are percent to total sample size in each state and by each indicator.
N refers to total number of sample farmers.

Based on grouped data, however, the cross tabulation did not capture the relationship between adoption or non-adoption and the growers' socioeconomic characteristics and estate profiles. Thus, econometric methods were used to analyze and estimate the effects of the socioeconomic characteristics and estates profiles on the adoption and non-adoption.

EMPIRICAL FRAMEWORK FOR ESTIMATION OF DETERMINANTS

One qualitative response in the sample survey was whether or not a grower is an adopter of a CLR management practice. This response can be quantified by dummy endogenous variables and hence the determinants of adoption or non-adoption may be estimated using a binary logit model.[8] The general framework for estimation of the model follows.

Framework for Estimation

The binary logit model equation for *i*th household adopter is:

$$\ln\left[\frac{\rho_{ij}}{1-\rho_{ij}}\right] = \alpha_j + \beta_{1j}\cdot X_{1i} + \beta_{2j}\cdot X_{2i} + \cdots + \beta_{Kj}\cdot X_{Ki} + \varepsilon_i\{i = 1,2,\cdots,575\} \quad (1)$$

where ln is the base of natural logarithms; ρ_{ij} is the probability (defined by the standard cumulative logistic probability distribution function) of adopting the *j*th CLR management practice; $(1-\rho_{ij})$ is the probability of non-adopting the *j*th CLR management practice;

8 A presentation on statistical assumptions and construction of logit model is available in Chapter 17 of Green (2011).

(X_{1i} … X_{Ki}) is the socioeconomic and estate profile variables for *i*th grower; ε is the random disturbance term; and $\{\alpha_j, \beta_{1j}.....\beta_{Kj}\}$ is the intercept and slope parameters to be estimated. The model in equation (1) is inherently non-linear and estimated by the technique of non-linear maximum likelihood estimation and separately estimated for *j*th CLR management practice.

Next, let the estimated model in equation (1) be equal to the equation below. The asterisk (*) indicates the estimated value of the probability and parameters in equation (1). Then,

$$\rho_{ij}* = \frac{\ln(Z_{ij}*)}{\{1+\ln(Z_{ij}*)\}} \quad (2)$$

where Z_{ij}* is the estimated logit and is equal to:

$$\ln\left[\frac{p_{ij}*}{1-p_{ij}*}\right] = [a_j* + \beta_{1j}*.X_{1i} + \beta_{2j}*.X_{2i} + \cdots\cdots\cdots + \beta_{kj}*.X_{ki}]$$

Thus, equation (2) gives the estimated probability of adopting the *j*th CLR management practice, given the configuration of socioeconomic and estate profile variables.

The elasticity is computable at its sample mean value [$A(X_i)$] as follows.

$$\eta_{ij} = A(X_i)\cdot(1-\rho_{ij}*)\cdot\beta_{ij}* \quad (3)$$

Variable Descriptions

Table 8 summarizes the variables used for the estimations.[9] The data used to measure these variables are from the sample survey of 575 growers, as described in the earlier section. Table 9 presents the descriptive statistics of all variables used in the estimations and Table 10, the simple correlation coefficients. The mean of the dummy variables is the proportion of the sample households having the value of dummy variables equal to 1. For instance, the mean of dummy variable I-1 (slope of estate) shows that about 67 percent of the estates are located with medium slope. Of the non-dummy variables, the highest variability in terms of standard deviation is evident in the altitude variable. The wide range of land size variable (i.e., I-9 and I-10) is due to the inclusion of both small and non-small land sizes in the sample. Simple correlation coefficients between socioeconomic and estate profile variables are not reported because they are not interpretable in economic terms. Multicollinearity among the independent variables is evidently absent.

RESULTS OF ESTIMATION

Table 11 presents the estimation results of six models by pooling the sample of all the regions. All results are presented by the estimated intercept and slope coefficients and their asymptotic *t*-ratio. In addition, goodness of fit for the entire model is presented by the log-likelihood test statistic and chi-square test. The test showed significant results for all models. Estimated coefficients of all estate profile variables are statistically significant, except the coefficient of the slope variable. Among the socioeconomic variables, age of household head, social caste, economic status, and total size of bearing area indicated significant influence on adoption of fungicides for CLR management. For expositional purposes, all results are interpreted according to statistically significant coefficients.

The estimated coefficient of altitude

9 Price of fungicides and income from coffee cultivation may be other important economic variables but were not included in the estimations. This exclusion was due to incomplete reporting of (1) coffee production and sales details (e.g., by cherry or parchment or clear coffee) and (2) labor inputs for different rounds of fungicides by respondent farmers for the reference years, 2008–09 and 2009–10.

Table 8. Variable descriptions and measurement

Name	Definition	Measurement
D-1	Adopter of Bordeaux mixture	1 if adopter of Bordeaux mixture (1 or 2 times), 0 otherwise
D-2	Adopter of systemic fungicides	1 if adopter of fungicides (1 or 2 times), 0 otherwise
D-3	Adopter of BM&SF	1 if adopter of BM&SF (one or two times), 0 otherwise
I-1	Slope of estate	1 if medium slope; 0 otherwise
I-2	Altitude of estate(1)	Observed values (in feet)
I-3	Annual rainfall (1)	Observed values (in inches)
I-4	Aspect of estate	1 if the aspect is Northern, 0 otherwise
I-5	Age of head of household	Observed values (years)
I-6	Social caste	1 if belongs to general category, 0 otherwise
I-7	Education of household head (HH)	1 if higher education, 0 otherwise
I-8	Economic status of household	1 if holder of BPL card, 0 otherwise
I-9	Total size of land owned	Observed values (in acres)
I-10	Total size of bearing area	Observed values (in acres)
I-21	Altitude of estate(2)	1 if altitude is ≤3,500 ft, 0 otherwise
I-31	Annual rainfall (2)	1 if the annual rainfall is >50 – ≤100, 0 otherwise
I-91	Total size of land owned (small farmer)	1 if owns <25 acres of total land, 0 otherwise
I-101	Total size of bearing area (small farmer)	1 if owns <25 acres of total bearing area, 0 otherwise

Table 9. Descriptive statistics

Variables	Mean	Standard deviation	Minimum	Maximum
D-1	0.692	0.462	0	1
D-2	0.659	0.474	0	1
D-3	0.574	0.495	0	1
I-1	0.666	0.472	0	1
I-2	3378.687	504.222	2000	4600
I-3	74.616	16.091	40	140
I-4	0.268	0.443	0	1
I-5	51.068	10.893	26	85
I-6	0.532	0.499	0	1
I-7	0.216	0.412	0	1
I-8	0.287	0.453	0	1
I-9	13.953	31.722	1	422
I-10	11.486	24.244	0.5	250
I-21	0.673	0.470	0	1
I-31	0.830	0.376	0	1
I-91	0.906	0.292	0	1
I-101	0.923	0.266	0	1

Note: Description of notations is as given in Table 8

Table 10. Simple correction coefficients

Variables	D-1	D-2	D-3	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-21	I-31	I-91	I-101
D-1	1.00																
D-2	0.54	1.00															
D-3	0.77	0.83	1.00														
I-1	-0.04	-0.12	-0.09	1.00													
I-2	-0.45	-0.51	-0.43	0.15	1.00												
I-3	0.33	0.37	0.34	-0.05	-0.33	1.00											
I-4	0.11	0.08	0.08	0.11	-0.05	0.09	1.00										
I-5	-0.01	-0.05	-0.08					1.00									
I-6	0.27	0.35	0.25					0.08	1.00								
I-7	0.07	0.03	0.03					-0.01	-0.01	1.00							
I-8	-0.27	-0.24	-0.24					-0.13	-0.28	-0.17	1.00						
I-9	0.03	0.01	-0.01					0.13	-0.06	0.40	-0.21	1.00					
I-10	0.05	0.03	0.02					0.15	-0.04	0.40	-0.22	0.94	1.00				
I-21	0.40	0.45	0.38					0.07	0.43	-0.02	-0.24	-0.01	0.04	1.00			
I-31	0.20	0.22	0.19					0.08	0.33	-0.22	-0.11	-0.12	-0.13	0.28	1.00		
I-91	-0.08	-0.08	-0.07					-0.14	0.00	-0.42	0.20	-0.72	-0.72	-0.07	0.11	1.00	
I-101	-0.08	-0.10	-0.09					-0.15	0.02	-0.37	0.18	-0.70	-0.77	-0.08	0.11	0.90	1.00

Note: Description of notations is as given in Table 8.

variable is negative in model 1, model 2, and model 3. This means that, other things being the same, the odds in favor of the growers with estates at higher altitudes to adopt the CLR management strategies are lower than those of growers with estates at lower altitudes. This result is consistent with the fact that CLR incidence is less for coffee grown at higher altitudes. Interestingly, the estimated coefficient of altitude variable in model 4, model 5, and model 6 is positive. This may be interpreted that, other things being the same, estates at lower altitudes (i.e., less than 3,500 ft) have a higher probability of adopting CLR management strategies.

The estimated coefficients of rainfall and aspect variables are positive in model 1, model 2, and model 3. This means that, other things being the same, estates with higher rainfall and northern aspect have a higher probability of adopting CLR management strategies than estates with lower rainfall and non-northern aspect. In models 4 and 5, the estimated coefficient of rainfall variable is positive, indicating that estates with annual rainfall of 50–100 inches have a higher probability of adopting CLR management strategies.

The impact of age is negative in all models. This result implies that a 1 percent increase in the adopters' average age will lead to a decline of 0.03 in the logarithm of the odds that the grower will choose to adopt CLR management strategies.

Social caste was included among the variables to estimate whether or not a grower's social category influences adoption of CLR management strategies. The estimated coefficient of the social caste variable is positive in models 2, 4, and 5. Thus, other things being the same, the odds for growers belonging to the general social category to adopt CLR management strategies are higher than those of growers in the other categories.

Economic status was included as a measure of household capacity to adopt CLR management strategies. All the models indicated a negative sign for economic status variable. Thus, a grower who holds a BPL card has less odds (about –0.6 in the logarithm of the odds) of adopting CLR management strategies than a grower with a non-BPL card or no card.

Size of land area (total or bearing) showed a mixed impact on adoption of CLR management strategies. For instance, the estimated coefficient of the variables relating to total land size and total land size of less than 25 acres is positive and insignificant, but that of total bearing area of less than 25 acres is negative and significant. Thus, small growers with higher bearing areas (closer to 25 acres) have lower odds in favor of adopting CLR management strategies.

Using equation (2), the probability of adopting CLR management strategies was calculated and is presented in the last row of Table 11. The estimated probability is relatively higher for models 1 and 6 than for other models. Notably, it is lowest for model 3 and model 6. This implies that, given the socioeconomic and estate variables, the probability of adopting BM&SF is relatively lower than adopting BM/SF. Further, the estimated probability is highest for model 5, which is adopting Bordeaux mixture as a CLR management strategy.

Using equation (3), the elasticity of the probability for all explanatory variables was computed and the results are reported in Table 12. In general, the elasticity of estate profile variables is higher than that of socioeconomic variables.[10] This implies that estate variables are of primary importance in CLR management.

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10 Qualitatively, the inclusion of either estate or socioeconomic variables does not alter the determinants of adoption of CLR management practices in Table 11. This was evident by the sign-preserving and statistically significant coefficients in trial estimations of equation (1), which included only estate profile or socioeconomic variables.

Table 11. Socioeconomic and estate profile determinants of adoption of CLR management practices in India: estimates of binary logit model

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	4.97 (3.88)***	6.245 (4.67)***	5.301 (4.29)***	0.352 (0.46)	1.51 (1.94)*	1.297 (1.84)*
Slope of estate	0.118 (0.51)	-0.313 (-1.31)	-0.192 (-0.9)	-0.012 (-0.05)	-0.438 (-1.92)*	-0.268 (-1.3)
Altitude of estate (1)	-0.002 (-6.36)***	-0.002 (-7.11)***	-0.002 (-6.49)***	NA	NA	NA
Annual rainfall (1)	0.032 (4.08)***	0.038 (4.84)***	0.036 (4.97)***	NA	NA	NA
Altitude of estate (2)				1.45 (6.35)***	1.56 (6.92)***	1.42 (6.43)***
Annual rainfall (2)				0.562 (1.94)*	0.471 (1.60)	0.546 (1.9)*
Aspect	0.443 (1.75)*	0.213 (0.85)	0.222 (0.99)	0.576 (2.34)**	0.387 (1.61)	0.368 (1.68)*
Age of household head (HH)	-0.017 (-1.72)*	-0.031 (-2.97)***	-0.033 (-3.49)***	-0.016 (-1.65)*	-0.029 (-2.95)***	-0.033 (-3.63)***
Social caste	0.127 (0.51)	0.488 (1.98)**	0.032 (0.14)	0.399 (1.69)*	0.851 (3.68)***	0.309 (1.44)
Education level of HH	0.333 (1.12)	0.021 (0.07)	0.074 (0.27)	0.491 (1.64)	0.099 (0.34)	0.089 (0.34)
Economic status of HH	-0.636 (-2.6)***	-0.447 (-1.72)*	-0.749 (-3.14)***	-0.794 (-3.45)***	-0.613 (-2.58)**	-0.856 (-3.78)***
Total size of land owned	0.004 (0.40)	0.007 (0.75)	-0.006 (-0.54)	NA	NA	NA
Total size of bearing area	-0.007 (-0.52)	-0.011 (-0.83)	0.001 (0.11)	NA	NA	NA
Total size of land owned (small farmer)	NA	NA	NA	0.24 (0.32)	0.956 (1.32)	0.878 (1.25)
Total size of bearing area (small farmer)	NA	NA	NA	0.501 (-0.59)	-1.76 (-2.13)**	-1.46 (-1.88)*
-2 Log likelihood Chi-square Number of observations	-274.93 157.73# 575	-263.65 208.39# 575	-306.87 169.07# 575	-290.97 128.01# 575	-286.96 163.93# 575	-327.25 130# 575
Estimated probability	0.734	0.699	0.579	0.723	0.670	0.579

Source: Estimated by using equations (1) and (2).

Notes: For model 1 and model 4, dependent variable is "adopter of Bordeaux mixture (1 if adopter, 0 otherwise); For model 2 and model 5, dependent variable is "adopter of systemic fungicides (1 if adopter, 0 otherwise); For model 3 and model 6, dependent variable is "BM&SF" (1 if adopter, 0 otherwise)

Figures in the parentheses are *t*-ratios

***, **, or * indicates that the *t*-statistic is significant at 1, 5, or 10 percent level.

# indicates that the Chi-square statistic is significant at 1 percent level.

NA refers to not applicable

Table 12. Estimated elasticity of probability of adoption of CLR management practices

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Slope of estate	0.021	–0.063	–0.054	–0.002	–0.089	–0.075
Altitude of estate (1)	–1.492	–2.004	–2.392	NA	NA	NA
Annual rainfall(1)	0.634	0.862	1.135	NA	NA	NA
Altitude of estate (2)	NA	NA	NA	0.267	0.320	0.402
Annual rainfall(2)	NA	NA	NA	0.127	0.119	0.191
Aspect	0.032	0.017	0.025	0.042	0.032	0.041
Age of head of household (HH)	–0.232	–0.475	–0.711	–0.221	–0.449	–0.712
Social caste	0.018	0.078	0.007	0.058	0.138	0.069
Education level of HH	0.019	0.001	0.007	0.029	0.007	0.008
Economic status of HH	–0.048	–0.038	–0.090	–0.062	–0.054	–0.103
Total size of land owned	0.014	0.029	–0.035	NA	NA	NA
Total size of bearing area	–0.021	–0.037	0.007	NA	NA	NA
Total size of land owned (small farmer)	NA	NA	NA	0.059	0.264	0.335
Total size of bearing area (small farmer)	NA	NA	NA	–0.126	–0.496	–0.567

Source: Estimated by using equation (3)

Note: NA refers to not applicable

CONCLUSIONS AND IMPLICATIONS

This paper developed a framework for estimating socioeconomic and estate profile determinants of adoption or non-adoption of CLR management practices in India. The framework was implemented using data from 575 household growers in traditional coffee-growing regions.

From the descriptions and analyses, it can be said that socioeconomic and estate variables have important impacts on adoption of CLR management practices. The important variables include altitude, rainfall, age of household head, economic status, social caste, and size of bearing area of Arabica coffee cultivation. Further, the probability of adopting BM&SF is relatively lower than adopting BM/SF; the highest probability of adoption is evident for Bordeaux mixture. These results add new insights to the understanding of factors that determine the management of CLR by household farmers in a developing country like India.

The above results have several policy implications. First, a public policy for promotion of CLR management practices may be focused on the following: (1) estates located in particular altitudes and with certain rainfall levels, (2) households headed by the young or middle aged, (3) households of certain economic status, identified in the study as BPL card holders, and (4) growers with less than 25 acres (10.12 ha) of bearing area. This approach to a promotional policy will have special relevance for poor and small growers whose livelihood depends on income and employment in coffee cultivation activities.

Second, coffee farming is subject to the mercy of both market conditions and the natural environment. Market conditions include labor markets (e.g., high wages, non-availability of timely, efficient, and adequate labor). Environmental factors include untimely and erratic rainfall. While market and environmental factors are beyond the

control of individual farmers, they affect the management of CLR as exogenous constraints. Proper insurance coverage to meet exigencies is needed. The results of this study may offer socioeconomic and locational justifications for the design of policy interventions that would provide coffee growers relief from such exogenous problems.

Subject to comparability of socioeconomic structures and locational factors, the results and implications presented in this paper may be relevant and applicable also to other Asian countries where Arabica coffee cultivation is affected by CLR and its management is by chemical sprays. However, many other economic variables (e.g., price of fungicides and gross earning from coffee cultivation) other than those considered in this paper may influence decisions on CLR management. The results and implications of this study may be further explored by inclusion of such variables.

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REFERENCES

Avelino, J., H. Zelaya, A. Merlo, A. Pineda, M. Ordonez, and S. Savary. 2006. "The Intensity of a Coffee Leaf Epidemic is Dependent on Production Situations." *Ecological Modelling* 197 (3): 431–447.

Coffee Board. 2011. *Database on Coffee*. Market Intelligence and Statistical Unit, Coffee Board, Bangalore, India.

———. 2009a. "Diseases of Coffee Leaf Rust." *Extension Folder No.17/2009*. Directorate of Research, Central Coffee Research Institute, Coffee Research Station, Chikmagalur, India.

———. 2009b. "Coffee Varieties from CCRI: Arabica." Extension Folder No.1/2009. Directorate of Research, Central Coffee Research Institute, Coffee Research Station, Chikmagalur, India.

Government of Karnataka. 2011. *Annual Report 2010-2011*. Food, Civil Supplies and Consumer Affairs Department, Bangalore, India.

Green, W. H. 2011. *Econometric Analysis*. New York: Prentice Hall.

Hillocks, R.J., N.A. Phiri, and D. Overfield. 1999. "Coffee Pest and Disease Management Options for Smallholders in Malawi." *Crop Protection* 18: 199-206.

NABARD (National Bank for Agricultural and Rural Development). 2011. *Model Bankable Scheme for Organic Coffee*. Technical Services Department, National Bank for Agricultural and Rural Development, Mumbai, India.

Phiri, N.A., R.J. Hillocks, and A. Jeffries. 2001. "Incidence and Severity of Coffee Diseases in Smallholder Plantations in Northern Malawi." *Crop Protection* 20: 325-332.

Reddy, D.R.B.. 2004. "Analysis of Cost of Production of Arabica Coffee in Kodagu Region, India." *Journal of Plantation Crops* 32(3): 53-57.

Reddy, D.R.B., P. Shivprased, and R. Naidu. 2003. "Estimation of Cost of Production of Arabica Coffee in Chikmagalur Region, Karnataka." *Journal of Coffee Research* 31(2): 106-118.

Schieber, Eugenio. 1972. "Economic Impact of Coffee Leaf in Latin America." *Annual Review of Phytopathology* 10: 491-510.