Research Article

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Determinants of R & R programme participation among coconut producers in Tamil Nadu: A Heckman two stage selection approach

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Abstract

The purpose of the study is to investigate the variables that affect coconut farmers' participation in Tamil Nadu's Replanting and Rejuvenation (R & R) scheme. Utilising a multi-stage sampling technique, a total of 120 coconut farmers were surveyed as respondents. Heckman's two-stage model was used with Probit model included in the first stage, and OLS was used to analyse the income regression in the second stage. Results reveal that age of farmer, education, farming experience, awareness of R&R programme, age of coconut tree, high incidence of pest and diseases, availability of irrigation facilities, and availability of credit for purchasing farm inputs are the most important determining factors for participation. These findings suggest that the R&R program requires to be implemented on a large scale with the aid of Coconut Development Board. This program should focus on removing old, senile, unproductive, and disease-advanced palm trees, replanting them with quality seedlings at subsidized prices, and revitalizing existing gardens through an integrated set of practices.

Keywords: Coconut, Heckman, CPC, Replanting, and Rejuvenation

Introduction

The agriculture sector is a key driver of sustainable economic growth in India. The country's diverse climate and soil make it ideal for growing a wide range of horticultural crops. Horticulture is gaining significant attention due to its contribution to the Indian economy by providing income and employment to millions of people in rural areas. Various horticultural crops have the potential to double farm income, achieve nutritional security, boost export revenues, provide employment for millions, and protect the land and ecosystem (Lathika and Kumar, 2005; Bhovi and Savadatti, 2017).

The coconut (*Cocos nucifera* L.) is a one of the valuable horticultural crops that provides food, oil, beverages, medicines, fibres, and a number of raw materials for the production of a wide range of products with substantial commercial value. In India, the coconut holds a prominent place among the horticultural crops with the production of coconuts in India has been expanding over time period between 2000-01 and 2020-21. There has been an increase in coconut cultivation area from 1.82 to 2.15 million hectares, production from 12.67 to 22.96 billion nuts, and an average productivity increase from 6,951 to 10,668 nuts per hectare (Jayasekhar & Jacob, 2021; Narmadha and Karunakaran, 2022a). Every year, coconut farming expands throughout the southern states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Telangana. In Tamil Nadu, area under coconut was 4.42 lakh hectares with production of 5623 million nuts and an average yield of 12509 nuts/ha which was higher than national productivity during triennium ending of 2020-21(Narmadha and Karunakaran, 2022b). This improvement was due to

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many government of India sponsored schemes and programmes (Thamban *et al.,* 2016).

Replanting and Rejuvenation (R & R) of coconut gardens is one of the needful programme for coconut farmers. The Replanting and Rejuvenation (R&R) scheme was implemented by CDB during 2009–10. The main objective of scheme is to maximize coconut production and productivity by removing diseased, unproductive, old, and senile palms, replacing them with quality seedlings, and renewing the surviving palms using an integrated set of procedures. Through the State Agri./Hort. Department, the scheme is implemented on a project basis depending on state-specific challenges (Kappil *et al*., 2021). Based on the baseline survey, the project shall clearly specify the action plan and operation calendar, as well as the location, number of palms to be removed, area to be rejuvenated, number of seedlings to be transplanted, and so on. Contiguous areas of at least 25 to 50 hectares, where farmers have organized themselves into farmer collectives, are the focus of implementation for coconut producer societies (CPS) and coconut producer federations (CPF). In accordance with the rejuvenation component, a subsidy of Rs.15,000/ha will be given in two equal payments for the adoption of integrated management practices like balanced nutrition through fertilizer application, irrigation, and drainage, soil, and moisture conservation practices, and the growing of green manure crops (Veerakumaran and Vinaikumar, 2019).

The majority of the farmers who took part in the R&R programme have observed improvements in their revenue as a result of gaining access to input packages. In this context, this study explores the factors that influence farmers' engagement in R&R programmes and how such participation affects crop productivity and farm income.

Methodology

A multistage sampling procedure was adoptedand using well planned schedule and data were collected. At the first stage, Tamil Nadu was chosen specifically due to its prominent position in coconut production in the country. To represent the entire state, three districts from the western and Cauvery delta zones were selected based on the coconut production statistics. In the western zone, the districts of Coimbatore (88, 467 hectares and 1323 million nuts produced) and Tirupur (63,012 ha and 420 million nuts produced) were chosen. Thanjavur district was selected from the Cauvery delta zone and has an area of 39,962 ha and a production of 567 million nuts. Thus, the selected districts accounted for 43.02 per cent of the state's coconut area and 45.24 per cent of its nut production**.** At the next stage, from each of the selected districts, one block was selected based on the coconut production statistics. The blocks thus selected were Anaimalai from Coimbatore district, Udumalpet from Tirupur district, and Pattukottai from Thanjavur district. In the next stage, one village from each block was selected for the survey. In order to fulfill the requirements of the study, from each village, 20 beneficiary farmers under the Replanting and Rejuvenation (R&R) scheme and another 20 non-beneficiary farmers from the same location were selected totalling 120 respondents.

To determine the probability and extent of coconut farmers' participation as beneficiaries under the Replanting and Rejuvenation scheme (R&R), the Heckman two-step model was used (Amfo and Ali., 2020). The model was used to evaluate the decision of coconut farmers to participate in the R&R scheme (first stage); and the intensity to be continued under the R&R scheme (second stage).

A random utility function was used to model and observe the coconut farmer faced with the decision of whether to participate or not. The utility, a coconut farmer obtains from participating under the scheme, is represented by U_{iA}, and not participated by U_{i0}. Considering utility maximization and rationality, a coconut farmer participated if

$$P^* = U_{iA} - U_{i0} > 0 \quad (1)$$

The net utility P* can be expressed as a function of observed characteristics (Z_i) and an error term (ε_i) as:

$$P_i^* = Z_i \beta + \varepsilon_j;\ P_i^* = 1 \text{ if } P_i^* > 0 \text{ and } P_i^* = 0, \text{ otherwise} \quad (2)$$

where,

P_i^* = Coconut farmer participated (a dummy variable),

$P_i^* = 1$, if coconut farmer does not participate in the scheme,

$P_i^* = 0$, if not.

Z_i = Vector representing explanatory variables.

β = Vector of parameters to be estimated, and

$\square_j$ = Error term.

Not all coconut farmers will participate in the scheme. Hence, sample selection bias becomes an important econometric issue. The response variable is censored, and the criterion that the sum of residuals be equal to zero is violated. The Heckman two-step model was used to address the problem of sample selection bias in the study (Heckman, 1976). As a result, participation in the scheme by coconut farmers is a two-step procedure. The first step is to use a probit model to know the decision of coconut farmers to participate in the RR scheme. The second step is to use an Ordinary Least Square (OLS) estimator to identify the intensity or extent to which to continue, with the latter decision being dependent on the former. Hence, the technique in the second step might not be completely random, resulting in selectivity bias. Based on the foregoing, the Heckman two-stage approach appears to be a good fit for dealing with sample selection bias (Heckman, 1976). The model's first step (the selection equation) is as follows:

$$P_i^* = \beta_0 + \beta_1 X_i + \square_i \quad (3)$$

where,

P_i^* =An unobserved latent variable denoting a coconut farmer's decision to participate in an R&R scheme;

X_i = Explanatory variables;

β = Parameters to be estimated, and

$\square_i$ = Error term.

The observed binary variable is given a

$A = 1$ if $P_i^* > 0$ (Coconut farmers who participated in the scheme) (4)

$A = 0$ if $P_i^* \leq 0$ (Coconut farmers who did not participate in the scheme) (5)

The second step of the model (substantive equation) is estimated with an OLS estimator given as:

$$Y_i = \alpha_0 + \alpha_i Z_i + \mu_i \quad (6)$$

Eqn. (6) represents a sub-category of Eqn. 3, and it is only estimated for coconut farmers who participated in the scheme. An additional explanatory variable, the Inverse Mills Ratio (IMR), is utilized to adjust for self-selection bias in the main equation (Greene, 2008), resulting in Eqn. (7):

$$Y_i = \alpha_0 + \alpha_i Z_i + \delta i \lambda i + \mu_i \quad (7)$$

where,

Y_i = Farm income is hypothesized to be impacted by farmer's participation in R&R scheme;

Z_i = Explanatory variables

δ_i = Coefficient of the IMR (λ_i).

If lambda (λ) is statistically significant, sample selection bias is a problem, and Heckman's two-step estimation is appropriate (Marchenko and Genton, 2012).

Results and Discussion

The Heckman Two Stage Model's variables are listed in Table 1. The average age of the household head was 53 years old, and there were usually between 5 to 6 individuals living together. The educated families made up around 80%, and 75% of the farmers were aware of the R&R programme. Coconut trees were typically around 28 years old. In the study area, a high occurrence of disease and pests was reported about 76%.The 83% of respondents were enhanced with irrigation facilities. The average amount of coconut farming owned by the respondents was 6.54 ha. The cultivators who responded had an average of 22.5 years of experience in coconut cultivation.. Only 25% of respondents received cash credit for cropping, according to the study, which indicates that few respondents had access to loans. However, 68% of the households claimed to have access to farming information, and 38% stated that they received training in coconut cultivation.

Table 1. Variables for Heckman model

Variables	Measurement
Responsible variable	
Participation of the R&R scheme (P_i*)	1 = Coconut farmer participated in the scheme; 0 = otherwise
Farm income (Y_i*)	Rupees
Explanatory variable ($X_{i\ and}Z_{i)}$	
Age of respondents	Years
Education	1 = farmer has formal education, 0 =otherwise
Family size	Number of people
Awareness of scheme	1 = aware about the scheme, 0 = otherwise
Age of coconut farm	Years
High incidence of pests and diseases	1 = occurrence of pest & diseases, 0 = otherwise
Irrigation facility	1= Availability of irrigation, 0 = otherwise
Farm size	Hectares
Credit for coconut production	1 = Farmer has received credit, 0 = otherwise
Coconut Farming experience	Years
Training	1 = Farmer has received training, 0 = otherwise
Exposure to farming information	1= Exposure to farming information, 0 =otherwise

Empirical results

This section explains the determinants of participation in the Replanting and Rejuvenation (R&R) programme and whether participation in the R&R scheme affects farm income. Unobserved variables that may have an impact on both participation probability and farm income can be used to explain these relationships. A two-stage Heckman model (1979) was applied to generate statistically unbiased estimates of programme impacts. Two equations calculate the effects of farmer characteristics on their choices to participate in the R&R programme. It displays an unbiased statistical assessment of the effect of programme participation on farm income. As estimated by Probit and OLS, the outcomes of the Heckman Two-Stage model were used to address the participation of farmers in the replantation problem. Multi-collinearity among the variables did not cause any serious issues. The model's overall goodness of fit was shown by the model's Chi-square, which was statistically significant at the one per cent level. The Wald test result (χ^2 (13) = 171.06) demonstrated that the level of the diversification equation's coefficients was significantly different from zero and that the model satisfied the requirement for a good fit. The Inverse Mill's Ratio (IMR) was used to test for selection bias, which was significant. This implied that there was no selection bias in the data. The findings of the probit analysis used to determine the probability that an individual will participate in the Replanting and Rejuvenation (R&R) programme are presented in Table 2.

Age and age squared were used to attempt to quantify a potential curvilinear effect on R&R scheme participation, but they had no effect on the findings, hence age was included in the study. The age coefficient was negatively significant, indicating that older farmers have a lower probability of taking part in the R&R scheme. This indicates that risk aversion rises with age. Education had a strong relationship with the participation level, as to be expected. The degree of family participation increased by 0.21 percent with each additional year of formal education . Education most certainly improves a household's human capital, allowing the head of the household to seek out new information on technology, adopt new production techniques more quickly, and satisfy increasingly demanding management needs for coconut farming. The probability of participation improved by roughly 0.65 per cent for those households when they were aware of the R&R scheme, a positive and significant influence on their decision to participate.

The decision of coconut farmers to take part in the R&R scheme is considerably and favourably influenced by the high incidence of pests and diseases in coconut trees. This suggests that farmers who have older and ailing coconut trees are more likely to take part in R&R schemes designed to increase the yield of nuts per tree. Households with regular irrigation facilities are more likely to participate in schemes to obtain high-quality nuts, as irrigation facility appears to be a significant determinant of participation decision. The farm size shows a negative impact on R&R programme participation. Due to their small holdings, small farmers are very risk apprehensive, whereas large farmers are eager to participate in schemes in order to profit. The accessibility of institutional credit, as indicated by the credit coefficient's showing positive significance, indicates that farmers are more likely to participate in schemes when they want the credit facility because they are less dependent on unofficial sources, primarily money lenders. Thus, awareness, availability of irrigation facilities, and availability of credit are the most important determining factors for participation in the R&R scheme.

The results of the second stage impact analysis using gross farm income as the dependent variable are also shown in Table 2. For sample selection

Table 2. Estimates from Heckman two-stage model

Variables	Stage 1 (Farmers' participation in R&R scheme) Probit		Stage 2 (Farm Income) OLS	
	Coefficient	P-value	Coefficient	P-value
Age	-0.0988	0.001	-0.0739	0.052
Education	0.2121	0.067	0.0048	0.001
Family size	-2.3668	0.122	1.1348	0.023
Awareness	0.6527	0.000	0.0019	0.550
Tree age	0.0887	0.065	-0.0430	0.063
High incidence of pests and diseases	0.1413	0.820	-1.6087	0.067
Irrigation	0.1221	0.000	1.2840	0.012
Farm size	-0.1594	0.089	0.0213	0.010
Credit	0.2905	0.003	1.1567	0.017
Farm experience	-	-	0.0863	0.045
Training	-	-	0.0548	0.592
Farming info	-	-	-2.8503	0.861
Lambda (IMR)			**0.1032**	**0.586**
Wald $\chi 2$			**171.06**	**0.000 (Prob> χ)**
Total observation			**120**	
Censored observation			**60**	
Uncensored observation			**60**	

bias, the second stage is adjusted. To obtain precise and objective estimations, the impact equations' error terms are corrected using the inverse mill's ratio, lambda. The residuals that are shortened at the second stage of the OLS have an expected value called lambda. The second stage's coefficient estimates are used to ascertain whether and how household characteristics, farm size, and other variables affect farm income.

The results show that household head age had a significantly negative relationship with scheme participation, even if the variable did not affect whether a person chose to participate in stage 1. This means that for every increase in household head age, household income falls by 0.07 per cent. The decision of farmers to participate in the R&R scheme and the proportion of farm revenue are both considerably and favourably influenced by education. The amount of farm income will increase by roughly Rs,1.13 with the one rupee increase in family size, and the family size was positively significant at this stage, even if it was not significant in deciding to participate. In spite of being statistically insignificant, awareness of the scheme has a positive influence on farm income, indicating that raising awareness alone is likely to boost income.

Since older coconut farms typically have depleted soil nutrients and less productive older coconut trees, they are more vulnerable to the effects of climate change. Moreover, older coconut farms are more vulnerable to root rot and white fly infestations, which can result in the regular trimming and cutting of coconut trees. In addition, depending on the soil, weather, and agronomic practices, some coconut trees lose their productivity or die after 30 to 40 years, which is likely to lower yields and lower farm income. This suggests that farmers have a lower chance of making a profit from their farms if their coconut trees are older and have been affected by pests and diseases. This indicates that risk aversion rises with coconut tree age and affected trees, which decreased farm income by 0.04 and 1.60 per cent, respectively.

Not only does access to irrigation affect a household's decision to engage in the scheme, but it also positively and considerably influences farm income levels, as would be expected. Households with access to more irrigation have seen a 1.28 per cent rise in farm income. A large farm size typically favours increasing agricultural income. Farmers with larger coconut farms are more likely to increase their farm income because it demands additional resources. As a result, larger coconut plantations earn more money than smaller farms. Hence, farm income increases significantly with increases in farm size by 0.02 per cent. Better institutional credit availability is projected to lead to an increased income of 1.15 per cent for coconut growers.

Coconut farmers rely on using the information they have accumulated over the years when it comes to agricultural experience. Young coconut farmers, however unskilled, are more prone to seek out new sources of revenue in order to boost their annual income. Thus, a one per cent increase in farming experience indicates a 0.08 per cent increase in farm income. Other factors, such as training and exposure for getting farm information about the farm, were found to have no significant impact on farm income.

Conclusion

The main objective of this study was to investigate the factors that influence farmers' participation in R&R programme among a sample of 120 farmers in Tamil Nadu. By implementing Heckman two-stage model, we found that the age of farmer, awareness of R&R programme, availability of irrigation facilities, and availability of credit for purchasing farm inputs are the most important determining factors for participation. Since older coconut farms typically have depleted soil nutrients and less productive older coconut trees, they are more vulnerable to the effects of climate change, root rot and white fly infestations, which can result in the regular trimming and cutting of coconut trees. Some coconut trees lose their productivity or die after 30 to 40 years. Thus, the older coconut farms have higher tree density, which is likely to lower yields and lower farm income. This suggests that farmers have a lower chance of making a profit from their farms if their coconut trees are older and have been affected by pests and diseases. This indicates that risk aversion rises with coconut tree age and affected trees, which decreased farm income. It is recommended that the government, through the Coconut Development

Board, take action for the large-scale implementation of the R&R program. This program should focus on removing old, senile, unproductive, and disease-advanced palm trees, replanting them with quality seedlings, and revitalizing existing gardens through an integrated set of practices. To ensure the program's smooth operation, guidelines should be established to provide farmers with access to high-quality planting materials produced by state agencies and state agricultural universities at subsidized prices.

Author's Contribution

Conceptualization of research (KRK, NN); Designing of the experiments (KRK, NN, AK); Contribution of experimental materials (KRK); Execution of field/lab experiments and data collection (NN, AK); Analysis of data and interpretation (NN, KRK); Preparation of the manuscript (NN).

Declaration

Authors have declared that no competing interests exist.

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