RESEARCH ARTICLE

Factors Driving Decision Making on Soil Nutrient Management Practices Followed by Farmers of Karaikal Region of Puducherry U.T.

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ABSTRACT

Soil nutrient management plays an important role in maintaining sustainable soil health for the future generation. The state or innate ability of the soil to provide nutrients to plants in sufficient quantities and the right proportions is known as soil fertility. Sustainable Soil fertility was maintained by following proper nutrient management by following four R's such as the Right quantity of fertilizers at the Right time with the Right source and the Right placement. The prime first step toward sustainable farming is using an optimal amount of fertilizers as well as following the cropping pattern as per the scientific recommendation. The multinomial logit model was used to predict a nominal dependent variable in this study (SPSS version 28). In the outcome of the model, it can be observed that age, education, livestock, family size, cultivated area, distance to fertility material sources, level of soil fertility severity of soil nutrient depletion, tenure, recommended dose, residual effect and soil conservation measures are significantly contributing meaningfully to the model. Gender and awareness of soil fertilizer pollution show a negative effect on the choice of soil fertility management choices. If the farmers in the study area use integrated soil nutrient or fertility management compared with other nutrient management choices, sustainable use and management of agricultural land will be promoted. Using Soil Health Card promotes balanced use of nutrient sources by avoiding dumping or reducing the usage of fertility or nutrient sources.

Keywords: *Multinomial Logit; Soil Health Card; Fertilizer Use; Soil Fertility Management Practices; Decision Making;*

INTRODUCTION

Soil is the base for crop production and it supports the livelihood of human being around the earth by envisioning its hands by providing survival requirements. Soil nutrient management plays an important role in maintaining sustainable soil health for the future generation. The state or innate ability of the soil to provide nutrients to plants in sufficient quantities and the right proportions is known as soil fertility. The ability of the soil to produce crops under particular management techniques is known as soil productivity, and it is measured in terms of yields (Yirga and Hassan, 2008). All fertile soils are also productive, but not all productive soils must also be fertile. It could be caused by issues like flooding, saline or alkaline conditions, unfavorable weather, etc. The ability of the soil to produce crops with a high economic value and to sustain soil health without deterioration is referred to as soil fertility in modern usage. Sustainable Soil fertility was maintained by following proper nutrient management by following four R's such as the Right quantity of fertilizers at the Right time with the Right source and the Right placement. The fertilizer usage per hectare was highest in Puducherry state (285 kg/ha) followed by other states such as Andhra Pradesh (237 kg/ha), Telangana (231 kg/ha), Karnataka (176 kg/ha) and Tamil Nadu (164 kg/ha) (Fertilizer statistics, 2014-2015). The prime first step towards sustainable farming is using an optimal amount of fertilizers as well as following a cropping pattern as per the scientific recommendation. Higher usage of nutrient doses results in fertilizer dumping only it is not the justifiable process to produce crop output in a sustainable way. The farmer's decision-making plays a vital role in soil nutrient applications but decision-making relies on various factors like age, gender, education, livestock, family size, cultivated area, the distance of a farm from homestead (Kms.), distance

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to fertility material sources, level of soil fertility, the severity of soil nutrient depletion, *etc.,* The objective of the study is to determine the factors that drive farmers' choice of soil nutrient management practices.

MATERIAL AND METHODS

The multinomial logit model (MLM) is employed here to assess the factors that affect farmers' choices between organic, inorganic sources of nutrients, and integrated soil nutrient management. This model was chosen as it handles the case of a dependent variable with more than two categories as compared to the Probit model which deals with dependent variables with only two categories. Instead of having two dichotomous (0, 1) alternatives as in the multi-variate Logit or Probit models (Apind, 2015). To determine the factors that influence the choice of soil nutrient management, a multinomial logit model was used. A soil nutrient management practice is chosen among other alternative soil nutrient management practices and is therefore discrete. The probability of choosing any given nutrient management practice can be represented by and is given by the equation below as.

$$P_{ij} = \beta_0 + \beta_i X_i + e$$

i takes values (1, 2, 3) each representing choice of soil nutrient management practices the farmer uses only chemical fertilizers = 1, the farmer uses only organic fertilizers (defined as composted material made from decomposed plant material, farm yard manure, Green leaf manure, kitchen refuse and household waste)= 2, the farmer uses both organic and inorganic fertilizers (referred to henceforth in the study as "integrated soil nutrient management") =3). X are factors affecting the choice of a soil nutrient management practice, β are parameters to be estimated and is randomized error. With j as the alternative choices, probability of choosing soil nutrient management practice j is given by

$$Prob\ (Y_i = j) = \frac{e_{z_j}}{\sum_{k=0}^{j} e_{z_k}}$$

Where Z_j is choice and Z_k is alternative choice that could be chosen (Greene, 2000). The model estimates are used to determine the probability of choice of a soil nutrient management practice j given the factors that affect the choice X_i. With a number of alternative choices log odds ratio is computed as,

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = \alpha + \sum X_i\left(\beta_j - \beta_k\right) + e$$

P_{ij} and P_{ik} are probabilities that a farmer will choose a given soil nutrient management practice and alternative soil nutrient management practice respectively. $\ln\left(\frac{P_{ij}}{P_{ik}}\right)$ is a natural log of the probability of choice j relative to probability choice, k, α is a constant, β is a matrix of parameters that reflect the impact of changes in X on the probability of choosing a given soil nutrient management practice, is the error term that is independent and normally distributed with a mean zero. Marginal effects of the attributes on choice are determined by getting the differential of the probability of a choice and it is given by, every sub-vector of $(\delta) = \frac{\partial P_i}{\partial X_i} = pi\left(\beta_j - \sum_{k=0}^{j} P_k \beta_k\right) = P_i\left(\beta_j - \beta\right)$ enters every marginal effect both through probabilities and through weighted average. Table 1 shows the variables to be used in the multinomial logit model. Multinomial logit model Choice of a soil nutrient management practice is specified as shown below in equations 1 and 2.

$$P_{ij} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \text{......} \quad \textbf{(1)}$$

$$P_{ij} = \beta_0 + \beta_1 AGE + \beta_2\ GENDER + \beta_3 EDUCATION + \beta_4\ LIVESTOCK + \beta_5\ FAM\ SIZE + \beta_6\ FAR\ SIZE + \beta_7\ DFFH + \beta_8\ LSF + \beta_9\ INST\ PAR + \beta_{10} LAND\ TENURE + \beta_{11} REC\ DOSE + \beta_{12} LABOUR\ DAYS + \beta_{13} SCM + \varepsilon \text{.........} \quad \textbf{(2)}$$

The Multinomial logit model parameters (slope coefficients, intercept term) and descriptive statistics of explanatory variables are calibrated using the Statistical Package for Social Sciences (SPSS version 28).

RESULTS AND DISCUSSION

Socio-economic characterization of the farmers

In the aspect of gender distribution, as shown in Figure 1, majority of the farming households, (82.67 per cent), were male headed and Female headed farming households comprised only 18.33 per cent. In terms of education level of the households, from Figure 2, nearly 86 per cent of the respondents were literate and the remaining 14.17 per cent were illiterate.

In SPSS software, dependent variables were stored as nominal variables. The multinomial logit model was used to predict a nominal dependent variable in this study. The multinomial logit model allows the interactions between the chosen independent variables to predict the dependent variable. The multinomial logit model measures the change effect in the variation of one of the independent variables on the variation of the dependent variable and explains the variation. The effect of chosen independent variables was explained with the support of relative log odd ratios. From Table 3, final model is significantly predicting the outcome variable more than the intercept-only model. The parameter of the chi-square distribution used to test the null hypothesis is defined by the degrees of freedom in the prior column in Table 3.

Table 1: Description of variables used in the multinomial logit model

Abbreviation	Variable name	Description	Hypothesized effect
AGE	Age of the farmer	Years	+
GENDER	If the decision maker is Male /Female (Male=1, Female=0)	Dummy	+ or -
EDUCATION	Years of schooling	Years in formal education	+
LIVESTOCK	Units of livestock	0-Nil 1- ≤ 3 Numbers 2- 4 to 6 Numbers 3- 7 to 9 Numbers 4- ≥ 10 Numbers	+ or -
FAM SIZE	Family size	Number of persons	+
FAR SIZE	Farm size	Acres	+
DFFH	The distance of a farm from homestead	Kilometers	+
LSF	level of soil fertility	3=high 2=moderate 1=low	+
INST PAR	Institutional participation	1 if yes, 0 otherwise	+ or -
TENURE	Land Tenure	1 if own land, 0 otherwise	+ or -
REC DOSE	Adoption of SHC Recommended Doses of fertilizer	Following recommended dose 1 if yes, 0 otherwise	+ or -
LABOUR	Labour	Labour days	+ or -
SCM	Soil conservation measures taken	1 if yes, 0 otherwise	+ or -

Table 2: Descriptive statistics of socioeconomic profile

	N	Minimum	Maximum	Mean (μ)	Median	SD (σ)	Variance	CV (%)
Age	120	29.0	76.00	51.8	50.0	11.6	135.4	22.4
Family size	120	1.00	7.00	4.3	4.00	1.3	1.63	29.6
Experience in Farming	120	5.0	50.0	26.9	25.0	11.9	143.23	44.5

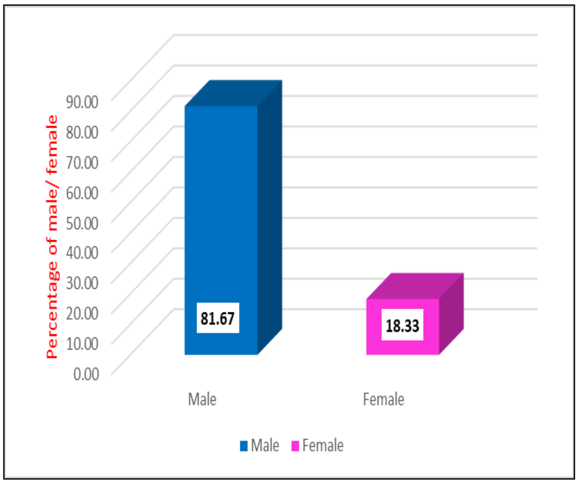

Figure 1. Gender distribution

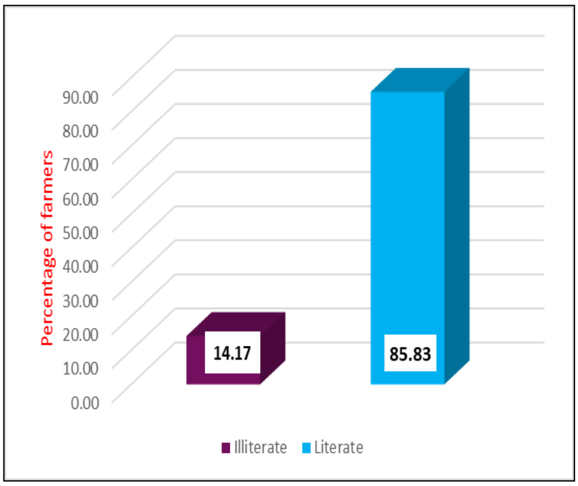

Figure 2. Literacy level

From Table 4, the Nagelkerke pseudo-R square indicates that 87.8 per cent of the total variations in the choice of soil nutrient management occurred due to the variations among the chosen predictor variables. The −2 Log likelihood or reduced model are enlisted in Table 4 and the results, it can be observed that age, education, livestock, farm size, level of soil fertility, adoption of the recommended dose, institutional participation and adoption of the recommended dose of fertilizers are significantly contributing meaningful to the model. Gender and family size shows a negative effect on choice of soil fertility management choices. Gender, land tenure, the distance of a farm from homestead (Kms.) and soil conservation measures were non-significant. Similar studies related to utilization intensity of Integrated Soil Fertility Management or Integrated soil Nutrient management methods were found to be negatively impacted by the household head's age, the farmers' impression of soil erosion, and the rented land tenure. Access to agricultural information, especially from farmer groups, which played a significant role in determining the intensity of use of ISFM by their various households, was found to have an impact on the percentage of ISFM practices used by different households in an evaluation of the factors that determine the level of usage of the ISFM in Western Kenya (Nambiro et al., 2012). Macharia et al. (2012) identified that the Gender of the farmer influenced the utilization of Integrated Soil Fertility Management or Integrated soil Nutrient management methods and they found that Labour days used for the application of soil fertility materials is shown to reduce the probability of using only inorganic soil fertility materials by 0.03. This implies that the availability of labour for the application of the materials increased the tendency of the maize farmers to use Integrated Soil Nutrient or fertility Management methods instead of using only inorganic soil fertility materials by considering a sustainable future. Makhoka et al. (2001) explained that farm size had a negative effect but an important effect on the use of Integrated Soil Nutrient or fertility Management methods, which in their study was negative and non-significant. Similar results were identified by Oluoch (2004), Habil (2012), Geta (2013), Bonabana (2016) and Khonje (2022) and their results concluded that socio-economic factors play a vital role in decision-making to adopt and follow any soil management practices.

Table 3: Model fitting information to predict the performance levels

Model	-2 Log Likelihood	Likelihood Ratio Tests		
		Chi-Square	Df	Sig.
Intercept Only	281.863	98.77	77	0.002***
Final	187.952			

Table 4: Empirical model for identifying the factors driving decision-making on soil nutrient management practices

Effect	Model Fitting Criteria	Likelihood Ratio Tests	
	-2 Log Likelihood of Reduced Model	Chi-Square	*P*-value
Intercept	113.332	7.023	0.017***
Age	87.833	5.524	0.055**
Gender	100.901	12.426	-0.661[NS]
Education	76.040	2.731	0.045**
Livestock	94.955	10.646	0.001***
Family size	11.735	1.592	-0.061
Farm size	115.479	11.170	0.001***
The distance of a farm from homestead (Kms.)	129.068	1.758	0.624 [NS]
Level of soil fertility	145.423	5.114	0.016**
Institutional participation	130.612	4.375	0.004***
Land Tenure	141.305	2.815	0.421[NS]
Adoption of recommended Dose	108.553	8.244	0.041**
Labour	96.352	16.042	0.001***
Soil conservation measures	141.305	0.996	0.802 [NS]
Wald Chi2	**243.216**		
Prob>Chi2	**0.001**		
Cox and Snell	**0.878**		
Nagelkerke	**0.979**		
McFadden	**0.923**		

N=120, *** Significant at 1%, ** 5% and *10%.

CONCLUSION

The study focuses on factors which determines the soil nutrient methods or fertility methods. The Nagelkerke R-square indicates that 87.8 per cent of the total variations in choice of soil nutrient management is occurred due to the variations among the chosen predictor variables. The results from the study shows that insignificant predictor variables Gender, land tenure, the distance of a farm from homestead (Kms.) and soil conservation measures. The outcome of the model, it can be observed that age, education, livestock, farm size, level of soil fertility, adoption of recommended dose, institutional participation and adoption of recommended dose of fertilizers are significantly contributing meaningful to the to the model. Gender and family size shows negative effect on choice of soil fertility management choices. If the farmers in the study area uses integrated soil nutrient or fertility management compared with other nutrient management choices, sustainable use and management of agricultural land will be promoted. Using Soil Health Card promotes balanced use of nutrient sources by avoiding dumping or reduced usage of fertility or nutrient sources.

Abbreviations

SPSS- Statistical Package for Social Sciences ISFM- Integrated Soil Fertility Management

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

This is original research work and any work and/or words of others has been appropriately cited.

Consent for publication

All the authors agreed to publish this research article, competing interests there were no conflict of interest in the publication of this content.

Competing interests

Yes, there were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required. If anything is required from the MS, certainly, this will be extended by communicating with the corresponding author through corresponding official mail; jecon0102@gmail.com

Author contributions

Research grant-UGC NFOBC Fellowship, conceptualization- DSK and AV, Experiments-JR, DSK and AV Guidance -DSK, AV, DMR and BK Writing original draft - JR, DSK, AV, DMR and BK, Writing-reviewing & editing - JR, DSK, AV, DMR and BK

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