Minimum Tea Hectarage Hypothesis: The Case of Smallholder Tea Sub-Sector in Kenya

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ABSTRACT

Tea is planted in the high potential and prime lands in the humid and semi-humid agro-ecological zones. The population pressure in the tea growing districts is relatively higher than that of the neighbouring districts without the enterprise. The average area under tea in the smallholder sub-sector is approximately 0.27 ha. The high population density in tea growing zones coupled with escalating unemployment in the country translates into continued sub-division of tea farms to smaller sizes. This scenario is an overt potential threat to the future of the smallholder tea production in Kenya. The problem of continued sub-division of tea farms has degenerated into what has conveniently been termed as "uneconomic tea farm units". The objective of this study was to determine the minimum significant tea hectarage a tea farmer should have below which it would be termed as "uneconomic tea farm unit." A profit function model was fitted on 259 smallholder farms. The dependent variable was gross margin per farm per year. The independent variables were: number of tea bushes per farm per year, cost of fertilizer (Kshs.) per hectare per year, labour wage rate (Kshs.) per man-day per year in each farm and an hectarage dummy variable where D=1 for farms above a defined nominal farm size otherwise D=0. The regression analysis was done for every farm size hectarage in the whole sample. For each hectarage variable, the corresponding significance level of the hectarage dummy coefficient was recorded and their relationship summarised in a graph. The results indicated that farms with tea hectarage within $0.10 \leq X \leq 0.15$ ha are more profitable. It was concluded that tea farm sizes falling within this range were economically efficient at all observed prices of the variable inputs, given the distribution of the fixed factors of production. It meant that tea farms sub-divided to sizes falling within this range are more profitable. The most optimal tea farm size was found at 0.13 ha. However, any tea farm with an area below 0.10 ha could conveniently be termed as "uneconomic tea farm unit". It implied that tea farms sub-divided to sizes below this hectarage would not be economically viable. The policy implication is that the minimum hectarage that an "economic tea farm unit" can have when farm subdivision is done to the limit should be 0.10 ha (approximately 0.25 acres). It is believed that subdividing tea farms below 0.10 ha would lead to uneconomical farm units which would ultimately result to a decline in national tea production. Policy makers within the tea industry can therefore conveniently draw the bottom line of tea farm subdivision at 0.10 ha. It would save the smallholder sub-sector from fragmenting tea farms to uneconomical sizes.

KEYWORDS: Minimum, tea, smallholder.

1.0 INTRODUCTION

Tea is planted in the high potential and prime lands in the humid and semi-humid agro-ecological zones (Othieno 1991). The population pressure in the tea growing districts is relatively higher than that of the neighbouring districts without the enterprise (GoK 1999). For example, the population density in Kirinyaga, Nyambene, Nandi and Nyamira Districts with tea are 309, 153, 200 and 556 persons per km^2 respectively as compared to 145, 25, 60 and 257 persons per km^2 for the respective neighboring Nyandarua, Kitui, Transmara and Migori Districts without tea. In these cases, the population density is at least twice as much as that of the respective districts which do not grow tea. The average area under tea in the smallholder sub-sector is approximately 0.27 ha (Kenya Tea Development Agency 1964-2000). The high population density in tea growing zones coupled with escalating unemployment in the country translates into continued sub-division of tea farms to smaller sizes. This scenario is an overt potential threat to the future of the smallholder tea production in Kenya. It is a great cause of concern to farmers, researchers and policy makers in the tea industry. In the past few years, incessant sub-division of tea farms has degenerated into what tea researchers in Tea Research Foundation of Kenya conveniently term as "uneconomic farm unit". Tea farmers sub-divide tea to their children in terms of the area under tea or the number of bushes. Farmers use various spacings to plant tea (GoK 1986). The most common one is the 1.5 x 0.75 m which results to a population of 8,611 plants per hectare. Others range from 1.2 m x 1.2 m to 1.2 m x 0.6 m with population densities of 6,730 to 13,448 plants per hectare respectively. Ultimately, different spacing result in different number of bushes on a fixed area of land. Due to this complexity, it is more prudent to determine the optimum tea farm size in terms of the area under the enterprise irrespective of the spacing used and the number of bushes planted. Also, land is a fixed resource whereas the number of bushes planted on a given area can vary within a farm as well as from farm to farm. Even when sub-division is done in terms of the number of bushes, ultimately it is the area under tea being fragmented. A perplexing question which then begs for an answer in this context is: what is the minimum significant economic hectarage a smallholder tea farmer should have below which it would be termed as an "uneconomic farm unit"? This phenomenon was conveniently termed as "minimum tea hectarage hypothesis".

2.0 METHODOLOGY

2.1 Theoretical Model Concept

The analytical procedure used was the profit function model. According to production economic theory, efficiency relates basically to the common observation that farm-firms that produce homogeneous outputs such as green leaf have different factor productivities (Yotopoulos and Nugent 1976). This phenomenon could be explained by the fact that different farms face different prices, or, different farms have different endowments of fixed factors of production or different farm-firms use different systematic behavioral rules. The use of profit function specifically allows for differences in the prices of the variable factors of production and in the quantities of the fixed inputs in its attempt to compare economic efficiency between farms with different endowments of the land resource to grow green leaf. Moreover, the profit function is used in such a way as to allow inter-farm differences in the ability to equate the value of the marginal products of the variable factors to their prices, that is maximize profits. It is an appropriate tool for measuring economic efficiency and both of its components, technical efficiency and price efficiency. However, not much is known about how disturbance terms in general should be introduced into the economic relationships (Lau and Yotopoulos 1971). It is assumed that the error in the profits is due to climatic variations, divergence of the expected output price from the realized output price, imperfect knowledge of the technical efficiency parameter of the farm and differences in technical efficiency among farms.

Lau and Yotopoulos (1971) used data from Indian Ministry of Agriculture and Food to estimate the profit function for the small and large farms, and to compare the relative efficiency between the two farm groups. The categorization of farms was on the basis of hectarage. Farms of less than ten acres were termed as "small farms" whereas those with more than ten acres were termed as "large farms". The results showed that small-scale farms were more economic efficient than large farms. The results implied that in agriculture the supervisory role of the owner-manager of the farm might be crucial for attaining high levels of economic efficiency. Kilungo (1998) estimated the profit function for the smallholder dairy farmers in Kiambu District in Kenya. The average herd size was found to be 1.2 cows per farm per year. Dairy farms with greater herd size than the average were categorised as large while those with less than the average were categorised as small. The results showed that, both farm groups were equally efficient. These results were attributed to the use of similar quantities of fixed factors of production, which could even include the non-measurable factors such as diligence and entrepreneurship of the small farmer.

The profit function model was used in this study to determine the minimum significant tea hectarage; the smallest economic farm unit should have in the smallholder sub-sector. The analysis was done for the whole sample of 259 smallholder tea farmers. This task was undertaken implicitly by factoring into the model a nominal size of tea hectarage, by use of a dummy variable.

Given a farm-firm with a production function with the usual neoclassical properties: -

$$V = F(X_1,\ldots\ldots,X_m;\ Z_1,\ldots,Z_n) \quad \ldots\ldots\ldots\ldots \quad 1$$

Where: V = output; X = variable inputs; Z = fixed inputs.

Restricted profit function (defined as current revenues less current total variable costs) can be written as follows:

$$P' = p\,F(X_1,\ldots, X_m; Z_1,\ldots,Z_n) - \sum_{j=1}^{m} q'_j X_j \quad \ldots\ldots\ldots\ldots \quad 2$$

Where: P' = Profit; p = Unit price of output; q' = Unit price of the j^{th} variable.

The fixed costs are ignored, since they do not affect the optimal combination of the variable inputs. Suppose that a farm maximized profits given the levels of its technical efficiency and fixed inputs, the marginal productivity conditions for such a farm are:-

$$p\, \delta(X\,;Z)\,/\,\delta X_j \;=\; q'_j \;=1,\ldots\ldots, m \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3$$

By using the price of output as the numeraire, we may define $q_j = q'_j/p$ as the normalized price of the j^{th} input. Equation 3 can then be rewritten as

$$\delta F/\delta X_j \;=\; q_j = 1,\ldots., m \qquad \ldots\ldots\ldots\ldots\ldots\ 4$$

By substituting equation 4 above into equation 2, Lau and Yotopolous (1971) used the profit function intrinsically allowing inter-farm differences in the ability to equate the value of the marginal products of the variable factors to their prices, that is to maximize profits. Within the framework of production theory, they derived an estimating profit function via the Cobb-Douglas production function, which could be used to measure economic efficiency and its components, between different farm size groups. To derive the working profit function model, one can start from a Cobb-Douglas or for that matter from any other form of a function. However, the analysis was casted in terms of the Cobb-Douglas function because it appears superior through tests of alternative functional forms (Yotopoulos and Nugent 1976).

For the Cobb-Douglas case, the logarithmic profit function for each farm group (Yotopoulos and Nugent 1976) is given by: -

$$\text{In}\,\pi^1 = \text{In}\,A^{1*} + (1-\alpha^*)\text{In}\,p + \alpha^*_1\,\text{In}\,q'_L + \beta^*_1\,\text{In}\,K + \beta^*_2\,\text{In}\,T \quad \ldots\ldots\ldots\ldots\ 5a$$

$$\text{In}\,\pi^2 = \text{In}\,A^{1*} + (1-\alpha^*)\,\text{In}\,p + \text{In}\,(A^{2*}/A^{1*}) + \alpha^*_1\text{In}\,q'_L + \beta^*_1\,\text{In}\,K + \beta^*_2\,\text{In}\,T \ldots\ldots\ 5b$$

Where: $\pi^{'s}$ = Money profit; q'_L = Money wage rate per day; p = Price of output; $^{1\ \text{and}\ 2}$ = Different farm groups.

If prices of outputs differ only across Districts or regions, then District or region dummy variables can be inserted to capture the effect of differences due to (In A* + (1-α^*)In p). This manipulation also allows for inter- District or interregional differences in the efficiency parameter in A*. Hence the final estimating equation consists of

$$\text{In}\,\pi = \alpha_o + S + \alpha^*_1\,\text{In}\,q'_L + \beta^*_1\,\text{In}\,K + \beta^*_2\,\text{In}\,T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 6$$

Where: π = Farm profit in money terms: (excluding interest on capital and land rent); q'_L = Money wage rate per day; K = Interest on fixed capital; T = Cultivable land; S = Hectarage dummy variable (with a value of 1 above a defined tea area and 0 below it); α_o = Constant; α^*_1, β^*_1, β^*_2 = Estimation parameters.

Equation 6 was adopted for analysis. The basic estimation equation in linearized double log form for green leaf production was presented as-

$$\text{Log (TGM)} = \beta_0 + \beta_1 \log(\text{NB}) + \beta_2 \log(\text{FC}) + \beta_3 \log(\text{LC}) + \text{D} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 7$$

Where: TGM = Tea Gross Margin per farm; NB = Number of tea bushes per farm; FC = Cost of fertilizer per hectare per year per farm; LC = Labour cost per manday; D = Hectarage dummy variable (with a value of 1 above a defined nominal farm size hectarage and 0 below it); β_0 = Constant term; β_1, β_2, β_3 = Estimation parameters.

2.2 Data and Model Variables

Primary data used in this study were gathered from smallholder tea farms in Kirinyaga and Nyambene Districts in East of the Rift Valley and Nandi and Nyamira in West of the Rift Valley. Multistage random sampling selection was adopted. A random selection of the number of buying centres in each factory was first undertaken after which a proportionate number of farms were randomly selected. The sample total in the four districts was 259. The data collected was on agronomic practices, input use, output, prices and extension in tea enterprise. The variables used in the model were computed from the cross sectional data collected.

The dependent variable was Tea Gross Margin (TGM). It was computed as tea gross output value less the total variable cost of tea in the year. Total variable costs of tea was the sum of fertilizer costs, cost of weed control, cost of pest control, cost of disease control and the cost of labour used in the course of the year. A common conceptual problem is how to determine the cost of family labour. The general principle is to value family labour at its opportunity cost; that is the benefit the family must forgo to participate in tea production. The wage rates for labour in many developing countries may not accurately reflect the opportunity cost of shifting labour from one enterprise to another. However, for most of the farm enterprises e.g. tea, coffee and pyrethrum there are peak seasons at planting, harvesting and plucking, when most rural workers can find employment in farms. During these seasons, farmers hire additional casual labour to supplement family labour. Willing family labour can also find employment in tea farms during this season. The market wage paid to casual labour is a good estimate of its opportunity cost and its marginal value product. Therefore, the market wage rate could be accepted as the economic value of rural labour (Gittinger 1982). However, during off peak seasons tea farmers lay off casual labour due to reduced tea plucking. As a result, there is surplus labour. The opportunity cost of labour during this period is less than the market wage rate and is not easy to determine. Due to these difficulties, most studies (Kilungo 1998; Lau and Yotopoulos 1971; Sidhu 1974) have all used the market wage rate as the opportunity cost of family labour. This study also assumed that, most of the tea is plucked during the peak season when the market wage paid to casual labour is a good estimate of the opportunity cost of family labour. Therefore, the wage rate of labour (LC) was the product of total amount of green leaf (kg) in each farm per year and the plucking cost per kilogram divided by the total number of man-days (hired and family) used in the year. Fertilizer cost (FC) was computed on per hectare basis. This was because farmers do not buy fertilizer in the input markets. They get fertilizer at the factory point at a uniform price per bag for every factory, which does not reflect interfarm fertilizer price differences. Therefore, fertilizer cost/ha captures interfarm variations adequately. The number of mature tea bushes per farmer was the only fixed factor. It was expected to explain profit better than the area under tea. Interest on fixed capital was ignored because in small scale farming, it accrues to all the enterprises on the farm and not on tea enterprise alone.

The target variable for manipulation was the hectarage dummy, which represented defined nominal farm size hectarage. The starting point was the mean tea hectarage in the sample, which was found to be 0.45 ha. The hectarage dummy variable (D) was given a value of 1 for all the farms with tea area above 0.45 and 0 for all farms with area below the mean. It was expected that there would be differences in relative efficiency between tea farms with respect to different tea areas. Then the regression analysis was done for this case. This procedure of defining tea hectarage level successively and systematically followed by computation of the dummy variable and running the regression model with the other variables maintained was adopted for all the farm size cases in the sample ranging from the highest hectarage of 5.10 ha to 0.02 ha which was the lowest area under tea. There were only five cases above 2.0 ha whereas there was no case below 0.02 ha. The range used to set the hectarage dummies was 0.01. Thus, the regression models for all the cases were done. However, only the regression results of the lowest, highest and the significant range of nominal farm size hectarage were reported.

3.0 RESULTS AND DISCUSSION

The empirical estimates derived from the profit function model are presented in Tables 1 to 5. The model fitted the data well as indicated by the goodness-of-it statistics. The overall level of the F-statistic shows that the independent variables predicted the short run tea profit significantly.

The results on the test of influence of predictors on short run farm profits indicated that the coefficients of fertilizer cost per hectare and labour wage rate were positive and significant at 0.1 percent level for all the reported cases. This implied that they positively and significantly influenced tea farm profits. It further meant that there is room for farmers to increase the use of the respective inputs to the optimal level, just at the point where additional input use would reduce the profits. The coefficient of the number of bushes was positive and significant at 1% level for 2.0 ha in Table 1 and 0.09 ha in Table 5. It was significant at 5% level for 0.10 ha in Table 4. This coefficient was significant at 10% level for 0.15 ha in Table 2. However, it was insignificant for 0.13 ha in Table 3.

The relationship between the significance level of the coefficient of the dummy variable and the area under tea was closely monitored in the study. It was observed that as the area under tea decreased from 2.0 ha in Table 1 up to 0.13 ha in Table 3, the significance level of the dummy coefficient decreased from 0.631 to a minimum level of 0.003. From this lowest point, it increased erratically (Fig. 1) and climbed to a maximum level of 0.881 at 0.09 ha in Table 5. Finally, it dropped to 0.792 at 0.02 ha (Fig. 1). Above a farm size of 2.0 ha and below 0.02 ha, the hectarage dummy variable was automatically deleted from the model.

Table 1. Profit Function Regression Results for Smallholder Nominal Farm Size above and below 2.0 hectares

Log TGM		Log Linear Model		
Variable	β_1	S.E. β_1	t	Sig t
Constant	0.935	0.506	1.846	0.066
Log NB	0.326	0.089	3.643	0.000
Log FC	0.428	0.090	4.757	0.000
Log LC	0.643	0.053	12.040	0.000
D	-0.181	0.375	-0.481	0.631

Multiple R = 0.786; R^2 = 0.618; Adjusted R^2 = 0.611; Standard Error = 0.368

ANNOVA

	Sum of Squares	df	Mean Square	F	Sig. F
Regression	45.600	4	11.400	84.143	0.000
Residual	28.180	208	0.135		
Total	73.780	212			

Table 2. Profit Function Regression Results for Smallholder Nominal Farm Size above and below 0.15 hectares

Log TGM		Log Linear Model		
Variable	β_1	S.E. β_1	t	Sig t
Constant	1.067	0.504	2.117	0.035
Log NB	0.193	0.107	1.801	0.073
Log FC	0.474	0.092	5.176	0.000
Log LC	0.628	0.053	11.875	0.000
D	0.173	0.081	2.146	0.033

Multiple R = 0.791; R^2 = 0.626; Adjusted R^2 = 0.619; Standard Error = 0.364

ANNOVA

	Sum of Squares	df	Mean Square	F	Sig. F
Regression	46.179	4	11.545	87.001	0.000
Residual	27.601	208	0.133		
Total	73.780	212			

Table 3. Profit Function Regression Results for Smallholder Nominal Farm Size above and below 0.13 hectares

Log TGM			Log Linear Model	
Variable	β_1	S.E. β_1	t	Sig t
Constant	1.116	0.499	2.239	0.026
Log NB	0.146	0.105	1.393	0.165
Log FC	0.485	0.090	5.385	0.000
Log LC	0.629	0.052	12.077	0.000
D	0.243	0.080	3.037	0.003

Multiple R = 0.796; R^2 = 0.634; Adjusted R^2 = 0.627; Standard Error = 0.360

ANNOVA

	Sum of Squares	df	Mean Square	F	Sig. F
Regression	46.766	4	11.691	90.020	0.000
Residual	27.014	208	0.130		
Total	73.780	212			

Table 4. Profit Function Regression Results for Smallholder Nominal Farm Size above and below 0.10 hectares

Log TGM			Log Linear Model	
Variable	β_1	S.E. β_1	t	Sig t
Constant	1.008	0.500	2.015	0.045
Log NB	0.213	0.099	2.144	0.033
Log FC	0.456	0.090	5.090	0.000
Log LC	0.642	0.052	12.247	0.000
D	0.214	0.089	2.405	0.017

Multiple R = 0.792; R^2 = 0.628; Adjusted R^2 = 0.621; Standard Error = 0.363

ANNOVA

	Sum of Squares	df	Mean Square	F	Sig. F
Regression	46.331	4	11.583	87.773	0.000
Residual	27.449	208	0.132		
Total	73.780	212			

Table 5. Profit Function Regression Results for Smallholder Nominal Farm Size above and below 0.09 hectares

Log TGM	Log Linear Model			
Variable	β_1	S.E. β_1	t	Sig t
Constant	0.951	0.509	1.868	0.063
Log NB	0.316	0.101	3.116	0.002
Log FC	0.427	0.090	4.741	0.000
Log LC	0.641	0.054	11.964	0.000
D	0.019	0.127	0.150	0.881

Multiple R = 0.786; R^2= 0.618; Adjusted R^2= 0.610; Standard Error = 0.368

ANNOVA

	Sum of Squares	df	Mean Square	F	Sig. F
Regression	45.571	4	11.393	84.006	0.000
Residual	28.209	208	0.136		
Total	73.780	212			

The hectarage dummy coefficient was significant between 0.15 ha in Table 2 and 0.10 ha in Table 4. It has the lowest significance level of 0.003 at 0.13 ha in Table 3 which is significant at 1% level. It is significant at 5% level for 0.15 ha in Table 2 and 0.10 ha in Table 4. Outside this range, it is insignificant. Since the profit function is transformed into a logarithmic function before estimation, the coefficient of the hectarage dummy variable differentiates two groups of farms above and below a defined farm size. Therefore, the null hypothesis test becomes one of determining whether or not the coefficient of the hectarage dummy variable is significantly different from zero. The method of analysis used generated data on hectarage and the respective significance level. The relationship of the two variables was summarised in Fig. 1. The hectarage dummy coefficient had a minimum significance level of 0.003 at 0.13 ha in Table 3 which is significant at 1% level. It was interpreted as the most optimal minimum hectarage for an "economic tea farm unit" in the smallholder sub-sector.

Further more, the dummy variable coefficient had a positive sign from 0.08 ha and above. Hence farms with tea hectarage greater than 0.08 ha are relatively more efficient. However, the sign turned negative at 0.3 ha which means that now farms below 0.3 ha are relatively more efficient. The farms in this range can be expressed in inequality forms as $0.08 \leq X$ and $X< 0.3$ where X is a defined tea hectarage.

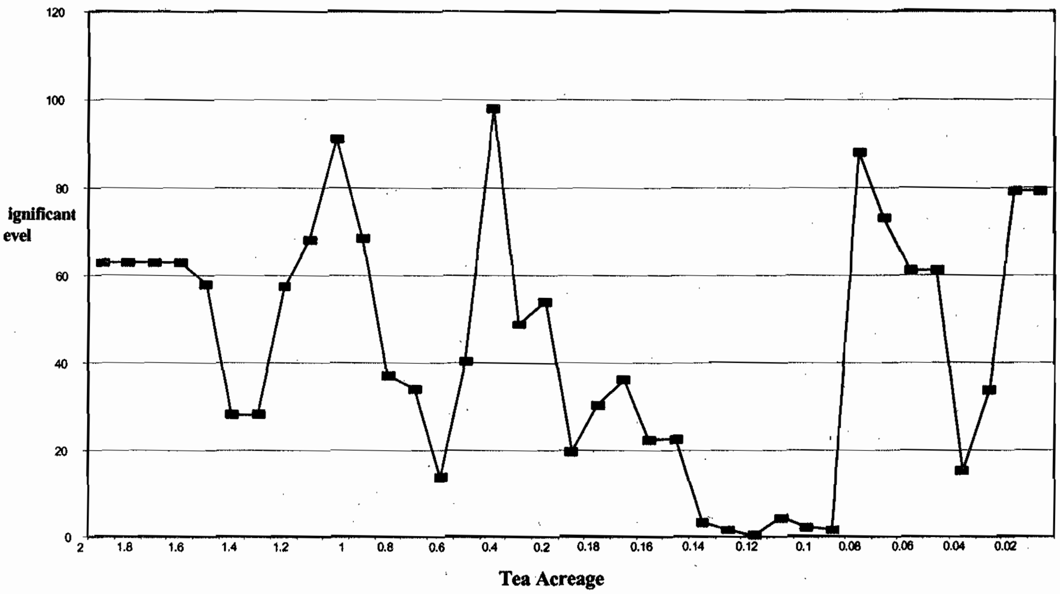

Figure 1. Minimum Significant Tea Acreage

The two inequalities can be expressed together as $0.08 \leq X< 0.3$ ha. Within this range, the subset of farm sizes which is positive and significant is $0.10 \leq X \leq 0.15$ ha. These results indicate that farms with tea hectarage within $0.10 \leq X \leq 0.15$ ha are more profitable, that is more economic efficient, at all observed prices of the variable inputs, given the distribution of the fixed factors of production. Thus, all tea farms in this subset are more successful in responding to the set of prices they face (Price efficiency) and/or because they have higher quantities of fixed factors of production, including entrepreneurship (technical efficiency).

The hectarage inequality $0.10 \leq x \leq 0.15$ is the range within which tea farms should fal when sub-division is done to the limit. It is the minimum significant economic hectarage for smallholder farms i.e. the range of 'economic farm units'. It implies that fragmented tea farms falling within this enequality would be efficient and profitable. Hence their operations will be able to cover the costs of production. The most efficient tea farm within the range was found to be 0.13 ha. It was the optimal 'economic farm unit' in the smallholder tea sub-sector. Tea farms with hectarage between 0.13 ha and 0.10 ha would still be economic farm units since they fall within the efficient range. However, farms falling below 0.10 ha would be inefficient and unprofitable. Therefore they qualify to be termed as 'uneconomic farm units' i.e. their sizes would be too small to cover the costs of production. These results answer the question of the minimum significant economic hectarage a smallholder tea farmer should have below which it would be termed as an 'uneconomic farm unit'. Thus, the search for and the determination of the hectarahge range for an 'economic farm unit' proves the 'minimum tea hectarage hypothesis'.

4.0 CONCLUSION AND POLICY IMPLICATION

This study established the minimum significant economic tea farm hectarage below which any farther fragmentation of tea farms would lead to 'uneconomic farm units'. The results showed that tea farm sizes falling within the inequality $0.10 \leq X \leq 0.15$ ha were economically efficient. This was interpreted as the range of minimum 'economic tea farm units'. It meant that tea farms sub-divided to sizes falling withing this range are efficient and profitable.

The study further revealed that the most optimal tea farm size was 0.13 ha. However, farms with an area below 0.10 ha could conveniently be termed as 'uneconomic units' since they are outside the range of minimum significant hectarage for smallholder farms. Hence, tea farms sub-divided to sizes below this hectarage are not profitable and would experience losses because they are not viable. The policy implication is that this is the minimum hectarage that a tea farm should have when farm sub-division is done to the limit. Hence sub-dividing tea farms below 0.10 ha (approximately 0.25 acres) would ultimately lead to a decline in national tea production. Policy makers within the tea industry can therefore conveniently draw the bottom line of tea farm sub-division at 0.10 ha. It would save the smallholder sub-sector from fragmenting tea farms to uneconomical sizes. Such a policy would ensure that even in the face of incessant land fragmentation, the operations of smallholder tea farms remain viable.

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