Chapter 4

The Estimation of Technical Efficiency of Smallholding Tea Plantation in North Bengal− A DEA Study

4.1 Introduction:

The structure of tea industry in West Bengal has undergone significant transformation with the adoption of the alternative production structure of tea smallholders (TSHs) since 1980s. It is perhaps the massive and unprecedented demand for tea in India's domestic market that is largely attributable for the adoption of this alternative model of tea growing. The areas where these establishments are now quite well spread-out include Uttar Dinajpur, Terai (the foothills of Darjeeling), Jalpaiguri, Alipurduar and Coochbehar. The TSH sector represents a system of production organization consisting of tea growers holding land areas (up to 10.12 hectares) to grow green leaf only and bought-leaf factories (BLF) holding no farms to grow green leaf but specializing in manufacturing tea using green leaves purchased from smallholders (Hayami and Damodaran, 2004). Thus, a noteworthy feature of this alternative model of production structure, consisting of independent small tea growers (STGs) and independent factories, is the separation of plantation agriculture from factory operation. This decentralized system contrasts with the older plantation system where plantation and manufacturing part of tea production are inseparably linked.

There are two distinct categories of TSHs− peasant plantations and relatively large plantations owned by business capital (Sarkar, 2014). In the initial phase, the sector was consisted with only relatively larger plantations owned by financially well-off people. However, during the last two decades, the growth of this sector has been distinctly attributable to setting up of plantation establishments by the peasant folk of this region on their own lands. Prior to becoming tea growers, they were largely small-holder subsistence farmers producing paddy, jute or other types of traditional crops for earning their livelihoods. This phase in which expansion of tea acreage is mostly attributable to smallholder tea growers with a peasantry background had its inception by the mid-1990s and is continuing unbrokenly till then. We discuss below how the TSH sector has emerged as a major stakeholder of the tea industry of West Bengal in recent time in terms of its significant contribution to total production of tea.

4.2 Contributions of STGs to the Tea Economy

The changing organizational arrangement of the tea sector of the region induced by high proliferation of STH sector has brought about a striking change in the composition of tea output in this region. This is clearly evident from the following table

Table4.1 Output Decomposition between Organized and STGs Sectors

Table1.	Production (in Million Kgs.)		
Financial year	Organised sector	Smallholder-BLF sector	Total
2011-12	192.94 (72%)	76.49 (28%)	269.43 (100%)
2012-13	194.69 (68%)	92.63 (32%)	287.32 (100%)
2013-14	214.63 (69%)	97.47 (31%)	312.10 (100%)
3-yearCAGR	3.62 %	8.41%	5.02%

Source: *Ministry of Commerce and Industry, GOI (2014)*

The above table 4.1 shows very clearly the smallholder-BLF sector's steady increase of production at an impressive rate over the years. In absolute terms, the production of the sector has increased from 76.49 million kgs in 2011-12 to 92.63 million kgs in 2012-2013. The production has further increased to 97.47 million kgs in 2013-2014. The share of this sector to total tea production of North Bengal appears to be above 30 percent between the periods 2011-12 and 2013-14 on an average. As far as sector-wise growth of production is concerned, the CAGRs of the organized sector and the small tea holder sector stand at 3.62 percent and 8.41 percent, respectively. These figures indicate that the growth rate differential between the two sectors is indeed sizeable–the CAGR registered in the unorganized sector is more than twice as high in comparison to the organized sector. If the present growth momentum of the smallholder sector continues unbrokenly, then it could reasonably be apprehended that it will come to dominate the organized sector in terms of production of tea in the years to come. The large-scale proliferation of tea smallholding sector is not a phenomenon specific to West Bengal. On the contrary, it is a common phenomenon which is evenly visible in the rest of the tea growing states of India including Assam.

In absolute number, there are now 35000 STHs with a total of 36000 hectares of land under tea cultivation in North Bengal. The sector accounts for 26 per cent of the total tea land in the State. But as most STHs still do not have official registration with TBI, the actual figures on number of growers and tea acreage are supposed to be much larger than the officially estimated figures.

4.3. The Objective of the Study

The development of STHs sector represents a significant agricultural transformation throughout the rural belt of North Bengal region which is essentially characterized by agricultural backwardness. This development has led a sizeable number of small and marginal farmers to set up tea plantations as their main economic activity. Earlier they used to earn their livelihoods from cultivation of traditional crops including paddy. The rapid increase in the number of STHs in the last decade is an ample proof to this assertion. The logical implication that follows from this changing pattern of occupational profile is that that the spread of STGs in this region is essentially attached with a rapid shift of land use from traditional type of farming to commercial farming of tea. In such a context, an important subject of inquiry would be to answer whether such a surge in the number of STGs and the subsequent change in land-use pattern did occur in order for seizing potential economic incentives in the form of productivity and efficiency gains leading to economic and remunerative use of land holdings. This chapter is an attempt to estimate plantation level technical efficiency (TE) **of** STGs in relation to allocation and utilisation of their land, labour and other productive inputs in order to produce maximum potential output, which is green tea leaf. This evaluation is necessary to identify whether outputs of STGs are produced at the maximum potential level, or alternatively, inputs are utilized at the minimum possible level. Moreover, this evaluation helps identify the sources of inefficiency and therefore, the opportunities for potential improvement of production performance of the STGs under consideration.

It deserves to be mentioned here that despite the rapid development of methodology of technical efficiency (TE) estimation and its application in different sectors of economy, research on technical efficiency in Indian tea industry is rather limited. Furthermore, such limited number of studies has been largely carried out to estimate TE in the conventional large estate sector using stochastic frontier production function model (Hazarika and Subramanian, 1999, Mahesh and Malaisamy, 2004, Maity, 2012). But application of DEA for estimation of TE in both the estate and small tea plantation sectors is still unfound in the literature. There is, thus, an emerging need for conducting DEA study in order to investigate the TE of smallholding tea sector in North Bengal region.

4.4. Methodology and Model

4.4.11 The Notion of Technical Efficiency

This section begins with an introduction of the idea of technical efficiency (TE) which constitutes an important tool for the measurement of productivity and efficiency performance of a production unit such as an industrial firm or an agricultural farm or a production unit in the service sector like a hospital, bank, public utility provider, educational institution etc. Since the publication of Farrell's (1957) seminal article on efficiency measurement, the frontier approach to TE analysis is quite well-established in empirical works. According to this approach, TE of a production unit is to be defined relative to some 'benchmark level' or "best practice frontier" which is constituted with best performing production units in a given sample. Hence, TE is a relative measure and indicates how close the actual or observed production unit is to the "best practice frontier". In other words, a measure of TE should indicate whether or not a firm is operating along the frontier. TE can be defined either from the input use side or from the side of production of output. Accordingly, there are two alternative definitions of TE− the input-oriented definition and the output-oriented definition. An input-oriented measure of TE reflects the minimum amount of inputs that is being utilized to produce a given level of output given the assumption of same technology for all the units under consideration. An output-oriented measure of TE, on the other hand, reflects the greatest amount of output that can be produced from a given amount of input given the technology of production. Thus, technical efficiency can be defined either in the form of the ratio of minimum potential to observed input required to produce the given output or the ratio of observed to maximum potential output obtainable from the given input (Lovell, 1993).It is customary to assign a technical efficiency score of 1 to production units on the frontier, and a score smaller than 1 to production units lying off the frontier. This essentially implies that the best performing unit is given a score of 1 and the performance of other units varies between 0 -1.

The techniques used for the estimation of TE under frontier approach are: (1) Stochastic frontier and (2) Data envelopment analysis (DEA). The former uses econometric methods of estimation of parametric function, whereas the latter uses nonparametric mathematical programming methods. The present study uses DEA to evaluate the efficiency of the small tea plantations in North Bengal on the basis of observed data. It deserves to be mentioned here that DEA application is still unfound in the literature as far as the small tea plantation sector of the study region is concerned.

4.4.2 Data Envelopment Analysis (DEA)

DEA is a "total factor productivity" analysis for measuring the relative efficiencies of a homogeneous set of production units, which are usually termed as decision making units (DMUs) in the DEA literature. The technical efficiency measure employed in DEA studies is the generalization of Farrell's single-input/ single-output technical efficiency measure to the multiple-input/multiple-output case by constructing a relative efficiency score as the ratio of a single virtual output to single virtual input as follows

$$\text{Technical Efficiency} = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}} = \frac{\text{virtual output}}{\text{virtual input}}$$

If there are n DMUs, each with m inputs and s outputs, the technical efficiency score of the k^{th} DMU is defined as:

$$\theta_k = \frac{u_1 y_{1k} + u_2 y_{2k} + ... + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + ... + v_m x_{mk}} \qquad k = 1, 2, \cdots\cdots, n$$

where $u_1, u_2, \cdots, u_s$ are weights assigned to outputs and $v_1, v, \cdots, v_m$ are weights assigned to inputs. Importantly, in DEA the weights are not known in advance, and are not even the same among DMUs. In fact, the weights for each DMU are determined in a manner that would maximize the efficiency score of each DMU by optimizing on that DMU under the constraints that the efficiency of each and every DMU should be less than equal to 1. Formally, for the determination of optimal weights of the k^{th} DMU, we solve the following problem

Maximise

$$\theta_k = \frac{u_1 y_{1k} + u_2 y_{2k} + ... + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + ... + v_m x_{mk}}$$

subject to

$$\frac{u_1 y_{1j} + u_2 y_{2j} + ... + u_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + ... + v_m x_{mj}} \leq 1 \qquad j= 1, 2, \cdots\cdots, n$$

$$u_1, \quad u_2, \quad ..., \quad u_s \quad \geq \quad 0 \qquad v_1, \quad v_2, \quad ..., \quad v_m \quad \geq \quad 0$$

which is known as the fractional programming (FP) formulation for efficiency analysis. One problem with this particular ratio formulation is that it is computationally intractable if addressed directly (Coelli, Rao and Battese, 1998). However, if the FP problem could be transformed into an ordinary linear programming (LP) problem, it would be computationally easier to solve. The transformation involves limiting denominator of the objective function equal to unity and only allows the linear programming to maximize the numerator. The unitization of the numerator value of θ implies that the DMUs seek to obtain the maximum output for unit input. The transformed LP can be written in the following form

LP_0:

Maximise

$$\theta_k = u_1 y_{1k} + u_2 y_{2k} + ... + u_s y_{sk}$$

Subject to

$$v_1 x_{1k} + v_2 x_{2k} + ... + v_m x_{mk} = 1$$

$$u_1 y_{1j} + u_2 y_{2j} + ... + u_s y_{sj} \leq v_1 x_{1j} + v_2 x_{2j} + ... + v_m x_{mj} \qquad j= 1, 2, \cdots\cdots, n$$

$$u_1, \quad u_2, \quad ..., \quad u_s \quad \geq \quad 0 \qquad v_1, \quad v_2, \quad ..., \quad v_m \quad \geq \quad 0$$

Intuitively, the above problem is run n times in calculating the relative technical efficiency scores of all the DMUs. A DMU_k is said to be technically efficient if $\theta^* = 1$ and there exists at least one optimal (v^*, u^*) with $v^* > 0$ and $u^* > 0$. Otherwise, the DMU_k is called technically inefficient (Charnes et. al., 1978). This definition is in perfect agreement with Farrell definition as it ensures that a DMU is technically efficient if it operates on the frontier.

In vector notation, $\mathbf{LP_0}$ can be written as

$\mathbf{LP_1}$:

$$\max_{u,v} \theta_k = u\, y_k$$

subject to

$$v\, x_k = 1$$

$$-v\, X + u\, Y \leq 0$$

$$v \geq 0 \quad u \geq 0$$

In this formulation, u is an 1×s row vector of output weights, y_k is the s×1 row vector of outputs, v is an 1×m row vector of input weights, and x_k is the m×1 row vector of inputs.

The formulation LP_1 is essentially expressed in primal form. Here the output vector and the input vector together form the constraint. However, the segregation of the constraint into output and input constraints is possible through dual transformation of the given primal problem, where the number of variables in one problem is equal to the number of constraints in the other. Furthermore, this segregation has the advantage that we could easily identify any non-zero input or output slacks even if θ is found to be of unit value.

We note that the primal problem LP_1 has $m + s$ variables (unknowns) in the form of v_i $(i = 1,2,\cdots,m)$ and u_r $(r = 1,2,\cdots,s)$ and $n + 1$ constraints. Hence in dual, there will be $m + s$ constraints and $n + 1$ variables. Let the dual variables be γ_k, $(\lambda_1, \lambda_2, \cdots\cdots, \lambda_n)$. The dual of LP_1 can be obtained as follows

$\mathbf{LP_2}$:

$$\min\ \gamma_k$$

subject to

$$\gamma_k\, x_k - X\lambda \geq 0$$

$$Y\lambda \geq y_k$$

$$\lambda \geq 0 \quad \gamma_k \text{ unrestricted}$$

The credit of introducing these primal and dual forms of input oriented LP goes to Charnes, Cooper and Rhodes. In DEA literature, these are known as CCR-I model. As the model is based on the assumption of constant returns to scale, the production possibility set is defined as

$$P^{CCR} = \{ (x, y): x \geq X\lambda;\ y \leq Y\lambda;\ \lambda \geq 0\}$$

where X is an $m \times n$ input vector, Y an $s \times n$ output vector, λ a column vector of non-negative weights.

In case of output oriented model, the dual objective variable would be the reciprocal of γ_k in LP_2. Defining dual objective as η_k, we have $\eta_k = \frac{1}{\gamma_k}$. Substituting for γ_k and assuming $\frac{\lambda}{\gamma_k} = \mu$ we get the following form

LP_3:

$$\max \eta_k$$

subject to

$$x_k - X\mu \geq 0$$

$$\eta\, y_k - Y\mu \leq 0$$

$$\mu \geq 0$$

The above form is also introduced by Charnes, Cooper and Rhodes as the output oriented CCR model in dual form. This is known as CCR-O model.

In 1984, Banker, Charnes and Cooper proposed a new model which takes into account consideration of variable returns to scale. In literature, this was referred to as BCC model. In this case, the production possibility set P^{BCC} is defined as

$$P^{BCC} = \{ (x, y): x \geq X\lambda;\ y \leq Y\lambda;\ e\lambda = 1;\ \lambda \geq 0\}$$

where e is a row vector with all elements equal to one and all are same as previous CCR model. Hence, a new condition is added in the BCC model, that is, $e\lambda = \sum_{j=1}^{n} \lambda_j = 1$. It enables the production frontier to be spanned by the convex hull of the existing DMUs. With the introduction of this particular condition, the combinations of DMUs are now allowed to find the best practiced DMU. Hence the input oriented BCC model in the dual form becomes

LP_4:

$$\min \theta_k$$

subject to

$$\theta_k x_k - X\lambda \geq 0$$

$$Y\lambda \geq y_k$$

$$e\lambda = 1,\ \ \lambda \geq 0$$

To find output oriented BCC model in dual form, we replace the dual objective variable $\theta_k$by its reciprocal defined as η_k and assuming $\frac{\lambda}{\Theta_k} = \mu$ to obtain the following formulation

LP_5:

$$\max \eta_k$$

subject to

$$x_k - X\mu \geq 0$$

$$\eta y_k - Y\mu \leq 0$$

$$e\,\square = 1, \quad \mu \geq 0$$

where η = a scalar, X = $m \times n$ input data matrix, Y = $s \times n$ output data matrix, x_k= $m \times 1$ input vector for DMU k, y_k = $s \times 1$ output vector for DMU k, μ = $n \times 1$ vector of non-negative constants, e=(1,⋯⋯,1), m = the number of inputs, s = the number of outputs and n= the number of DMUs. This is what is known as output oriented BCC model in dual form.

The constraints in LP_5 can be written as equations as shown below

$$x_k - X\mu - s^- = 0$$

$$\eta y_k - Y\mu + s^+ = 0$$

$$e\mu = 1$$

$$\mu \geq 0$$

where s^- and s^+ represent input excesses and output shortfalls, respectively.

Let an optimal solution to the above problem be $(\theta^*, \mu^*, s^{-*}, s^{+*})$. Given this, we can make a distinction between two widely used notions of TE, namely, Farrell efficiency and DEA efficiency. For a DMU, the definition of Farrell efficiency requires that $\theta^* = 1$ as an optimal objective value of the above linear programming problem. If $\theta^* < 1$, then the DMU under evaluation is inefficient. DEA efficiency, on the other hand, demands that all the following conditions are to be satisfied simultaneously

i) Score (η) =1

ii) Input excess (s^-) =0

iii) Production shortfall (s^+) = 0

This definition implies that an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input. The DEA efficiency, thus, does follow Pareto Koopmans condition and represents a refinement over the Farrell's definition of technical efficiency.

4.4.3 DEA Model Specification

DEA analysis requires choosing an appropriate DEA model to analyze the performance of DMUs as because the efficiency scores are normally sensitive to the specification of the model. This essentially implies that one could obtain different sets of efficiency scores from the same data set with alternative specifications of the model. This could lead to miscalculation of efficiency scores and subsequently, wrong projections of inefficient DMUs onto the efficient frontier.

As mentioned previously, DEA analysis is carried out by choosing any one of the two basic DEA models, which are the CCR and the BCC models. The criterion of making a choice between these two basic DEA models must depend on our insight about the production technology under which the sample of DMUs operate. Suppose that we have some *a priori* reasons to believe that the production technology is such that DMUs can expand or contract the input-output combination to any extent and these projected input-output combinations would remain within the production possibility set. In economic parlance, it implies that the production technology has constant returns to scale. If this be the description of the production technology, then the choice of the DEA model is clearly the CCR model. On the other hand, we may predict that "a production possibility set with a piece-wise linear production frontier" is a fair characterization of the production technology under which the observed DMUs are actually operating. With this prediction, we are essentially making no assumption about returns to scale, or alternatively, we are making the assumption of variable returns to scale. Now given this assumption, our choice would definitely be the BCC model for efficiency estimation.

In the present study, the BCC model has been chosen as the production of green leaf output is subject to variable returns to scale (VRS) for a number of reasons as described below. It is important to mention at the outset that not only economic factors alone, but other non-economic factors have role to play in the production of green leaf. Two such important factors substantiating VRS assumption in the present study are respectively, the climatic and soil conditions factors under which small tea plantations operate in the North Bengal region. It has been cited in the literature that the annual yield distribution and potential yield of green leaf is largely influenced by seasonal fluctuations in weather variables including rainfall and temperature (Panda et. al., 2003). As far as the study region is concerned, the rainfall variable is subject to both spatial and inter-temporal variation in terms of total amount and distribution throughout the season. This provides a good justification of the assumption of VRS. The second important factor justifying the assumption of VRS is the recognition of the fact that small tea plantations in different sub-regions of non-traditional tea area are characterized by differences among a set of soil properties including pH of soil, EC and organic matter content.

Another important consideration regarding model specification is whether to select an input-oriented or output-oriented model. Intuitively speaking, the choice of input-or output-oriented models depends upon whether the production units under consideration have fixed or variable quantities of resources to produce outputs. In this study, an output oriented DEA model has been chosen for the reasons as follows. For the estimation of technical efficiency, a number of variables used in the analysis are essentially fixed factors of production. These include land area, number of bushes in the plantation area, meteorological factors influencing tea yield, soil condition factors, permanent family labour employed in a garden and others. Thus, the DMUs would seek to determine by how much output quantity can be proportionally expanded given the set of non-discretionary inputs. Hence, we select the output oriented BCC model. The input-oriented DEA model is less relevant for the present study.

4.5 Data and Specification of Variables

The data for the study are primary data collected from nine locations where there has been high concentration of STGs. These include Islampur and Chopra regions of Uttar Dinajpur district, Kharibari and Chat hut regions of Darjeeling district, Fatapukur, JahuriTalma, Helapkri-Bhotpatti and the Panbari regions of Jalpaiguri district, and the Mekhliganj sub-division of Coochbehar district. The method of sample drawing in the study region was designed to be cluster sampling where clusters consisted of these locations of tea smallholders. This sampling method permits us to draw sample randomly when no single list of population members exists, but local lists do exist. In the context of the present study, it is important to mention that in the absence of any complete enumeration survey undertaken either by the TBI or the State

Government, no single exhaustive list of STGs in the region was available with the government departments. Only local lists of growers are available with primary producers' societies (PPSs) or self-help groups (SHGs) operating in different tea smallholding sub-regions. Due to this problem, the method of cluster sampling has been used for the collection of data from the survey respondents. In the context of the present study, the application of this method consists in drawing a random sample from a local list of growers who are enrolled with PPSs or SHGs. The sample used for this study is having a size of 124 STGs.

Small tea plantations employ multiple inputs to produce single output. The output is measured by the yield of green leaf in kg. The inputs used in the estimation of TE are categorized into two groups: (a) economic inputs and (b) inputs of soil condition parameters. The first set of inputs include area under tea, irrigation, different items of inorganic fertilizers such as nitrogen, potash and phosphate, organic fertilizer like cow dung, foliar nutrients and pesticide, number of plants and labour days employed. The second set of inputs include soil pH value, soil potash content, soil phosphorous content, soil sulphur content and soil nitrogen content. In total, fourteen input variables are used in the study. It is relevant to note here that the rule of thumb in selecting inputs and outputs of DMUs in a DEA model is as follows

$$\text{Number of DMUs} > \max\{(\text{inputs} * \text{outputs}), 3 * (\text{inputs} + \text{outputs})\}$$

4.6 DEA results

It has already been described in the model specification section that an output-oriented BCC model is used to estimate the technical efficiency of the small tea plantations in the study locations. The descriptive statistics for TE scores are presented in Table 4.2 below.

Table4.2.Descriptive statistics for TE Scores

Statistics (%)	Value (%)
Minimum TE	33.09
Maximum TE	100
Mean TE	91.64
Std. Deviation	15.67
Range	66.91

Source: *Field Survey, 2007-08*

It can be observed from the table that TE varies in wide range in which the minimum TE recorded is 33.09 percent while maximum TE is 100 percent. The mean TE of the DMUs is estimated to be about 92 percent which is appreciably of higher magnitude. This indicates that, on an average, there is a possibility of 8% potential yield improvement in this sector. In other words, this essentially means that if the inefficient gardens can increase their yield by grossly 8%, they are capable of achieving the efficiency level of best performing gardens.

The frequency distribution of TE measures has been presented in table,4.3

Table 4.3.The Percentage ranges of technical efficiency frequency

TE Range (%)	Distribution of Gardens (%)
30−49	2.46
50−59	5.65
60−69	5.65
70−79	6.45
80−89	4.03
90−99	4.84
score of 100	70.97

Source: *Field Survey, 2007-08*

A perusal of Table 4.3 reveals that about 70.97 percent of DMUs are found to be technically efficient with scores of 100 percent. They represent the best performing gardens within the sample. However, with the fixing of cut-off score for efficient DMUs to be 90 percent or more, the percentage of efficient DMUs improves to 75.81 percent. The justification for this flexible criterion, as argued by Ferreira (2005), is to avoid comprising the analysis through a DMU that stand outs as being outlier rather than for its true relative efficiency. Data recording errors and external factors are largely attributed for this flexibility. The DEA result showing more than two-third of the DMUs are operating with an efficiency score in the range 90−100 percent clearly proves the contention of the study that the proliferation process of STGs has been driven and subsequently, accelerated by the higher rate of productivity, and hence a larger prospect of profit, that this emerging sector is capable of generating.

The percentage of technically inefficient DMUs is observed to be 29.03 percent with a TE score of less than 100 percent. The study finds that a merely 2.46% of DMUs belong to the least efficient group with a TE score of less than 50 percent. Since the model fitted has an output-orientation, it could be inferred that the inefficient DMUs could potentially improve their yield while leaving their current input usage level unchanged.

4.6.1 Zone-wise Efficiency results of DMUs

The zone-wise distribution of efficient and inefficient DMUs is shown in the following table

Table4.4. Zone-wise composition of Efficient DMUs

District/Zone Symbol	Zone name	Mean TE (%)	% of Efficient DMU (zone wise)	% of Inefficient DMU (zone wise)
Uttar Dinajpur				
C	Chopra	100	100.00	0.00
I	Islampur	92	62.5	37.5
Darjeeling				
CH	Chat hut	89	83.33	16.67
KB	Kharibari	78	26.67	73.33
Jalpaiguri				
F	Fatapukur	94	62.50	37.50
JT	Jahuri Talma	100	100.00	0.00
HB	Hela Pakri-Bhot Patti	93	75.00	25.00
P	Panbari	90	64.00	36.00
Coochbehar				
M	Mekhliganj	81	28.57	71.43
Total		92	70.97	29.03

Source: *Field Survey, 2007-08*

The table shows that, as far as the total sample is concerned, 71 percent of the growers are observed to be using input resources efficiently to produce output, while the remaining 29 percent of them are operating inefficiently. There are two locations, namely, Chopra and Jahuri Talma, where all the STGs included in the sample are found to be technically efficient. These results are quite expected as these two locations might be considered as the hub of STGs. The regions where the percentage share of efficient STGs is above 70 percent consist of Chat Hut and Hela-Pakri and Bhot-Patti. The mean TE scores of these regions are estimated to be 89 percent and 93 percent, respectively, which are quite high. In the regions of Islampur, Fatapukur and Panbari, there is also a large number of efficiently functioning STGs. In each of these regions, the percentage share of best performing DMUs is above 60 percent. Along with this, the mean TE score in each of these regions is at least 90 percent or above. Thus, we see that there are seven out of nine zones under study where the lowest percentage of STGs operating on the efficient frontier stands at 60 while the highest percentage figure is seen to be 100. The areas with least percentage of efficient DMUs include Kharibari (26.67 percent) and Mekhliganj (28.57 percent). It may be noted in this connection that the mean TE scores for these regions have been found to be relatively low as compared with other regions.

It can be seen from the above table that even if the percentage share of efficiently functioning gardens varies substantially from one zone to other, the variation in mean TE score is of relatively smaller magnitude over most of these zones. This seems to imply that zonal differentials do not have much impact on achieving efficiency gains in small tea plantations. All zones are supposed to be grossly alike for tea farming. Thus, inefficiency is not really caused by regional differentials. Rather, the sources of inefficiency are to be identified in terms of under or over optimal use of resources at the level of individual growers no matter which location they belong.

4.6.2 Sources of Technical Inefficiency

The DEA analysis gives us useful information on how inefficient DMUs can improve efficiency by either decreasing inputs and/or increasing outputs. The following tables (table 4.5a and table 4.5b) provide figures on such input excesses and output shortfalls

Table4.5a.Input Excesses and Output Shortfalls

DMU Name	% of excess area	% of excess irrigat ion hr	% of excess nitro	% of excess potash	% of excess phosp hate	%of excess labour days	% of excess FNP	% of excess Dung	% of target output w.r.t to current output
CH3	0.00	0.00	44.02	30.87	18.64	40.33	6.17	28.25	303.32
CH4	0.00	0.00	48.29	19.31	0.00	35.60	0.00	0.00	263.07
F1	34.90	0.00	73.08	57.92	59.01	22.82	69.65	0.00	117.17
F4	8.72	52.98	71.18	64.04	66.75	25.73	21.96	0.00	106.68
F8	49.17	64.78	75.42	50.62	0.00	14.16	0.00	4.86	142.36
HB11	42.16	0.00	0.00	21.15	52.02	63.15	0.00	0.00	184.30
HB5	15.85	66.65	0.00	32.32	77.70	0.00	42.65	0.00	140.17
HB7	37.48	0.00	12.53	42.88	50.59	45.24	0.00	0.00	120.21
I1	0.00	29.08	62.04	57.26	67.99	0.00	68.55	16.32	129.53
I6	0.00	0.00	9.19	0.00	22.26	55.06	0.00	9.28	110.46
I8	0.00	0.00	12.17	0.00	65.05	54.12	34.83	16.20	148.08
KB1	0.00	83.44	0.00	0.00	0.00	60.62	0.00	75.82	143.34
KB10	0.00	0.80	7.82	0.00	0.00	16.89	0.00	0.00	105.33
KB12	0.00	61.44	34.55	14.88	0.00	17.12	0.00	76.96	191.51
KB13	10.18	60.32	56.44	53.06	0.00	47.99	0.00	22.52	147.87
KB14	12.04	0.00	27.73	58.58	0.00	42.43	0.00	63.25	175.28
KB2	11.82	47.79	3.47	0.00	0.00	0.00	42.95	0.00	121.79
KB4	47.17	96.62	5.74	5.74	0.00	0.00	0.00	62.90	102.55

Source: *Field Survey, 2007-08*

Table4.5b.Input Excesses and Output Shortfalls

DMU Name	% of excess area	% of excess irrigati on hr	% of excess nitro	% of excess potash	% of excess phosp hate	%of excess labour days	% of excess FNP	% of excess Dung	% of target output w.r.t to current output
KB6	0.00	41.76	30.05	60.72	72.60	0.61	13.49	76.45	140.54
KB7	8.15	0.00	23.17	0.00	0.00	30.05	17.21	66.02	131.46
KB8	0.00	94.01	47.42	0.00	44.63	49.94	0.00	69.01	205.04
KB9	0.00	85.62	0.00	0.00	0.00	49.77	0.00	51.94	170.58
M2	32.57	48.75	58.73	61.84	0.00	0.00	0.00	47.95	110.93
M3	50.42	0.00	18.42	0.00	0.00	69.09	0.00	83.04	113.66
M4	4.93	56.67	37.72	47.42	0.00	0.00	0.00	64.55	155.59
M5	27.80	0.00	57.61	47.23	41.43	0.00	0.00	40.40	154.18
M6	5.24	0.00	0.00	16.11	0.00	21.33	12.49	25.68	179.90
P14	28.31	67.28	82.69	75.11	0.00	43.32	0.00	78.52	114.81
P15	0.55	0.00	0.00	50.23	25.56	63.59	19.71	57.02	154.60
P18	0.00	72.35	0.00	0.00	0.00	48.41	0.00	28.13	135.85
P19	5.26	52.79	0.00	40.62	0.00	0.00	2.51	46.10	190.75
P2	0.00	0.00	19.40	23.62	48.49	0.00	0.00	0.00	168.47
P21-22	0.00	31.26	49.05	55.48	0.00	44.27	0.00	0.00	149.00
P24	27.09	0.00	0.00	29.17	9.12	45.29	0.00	0.00	130.72
P5-6	0.00	38.68	20.87	0.00	0.00	32.05	0.00	16.35	128.62
P7	0.00	39.48	50.79	49.72	0.00	0.00	0.00	3.61	109.11

Source: *Field Survey, 2007-08*

The above tables indicate that a number of STGs in the study region are operating inefficiently due to two reasons; i) using inputs at levels higher than the frontier level and ii) producing outputs at levels below the frontier level. Thus, there is ample scope for efficiency improvement for these STGs by either potential saving of inputs or potential improvement in output. As we can read from the above table, for CH3 to operate efficiently, the output of green leaf could be increased by about 300 percent without using additional amount of any input. At the same time, the use of nitrogen fertilizer, potash fertilizer and phosphate fertilizer could be reduced by 44 percent 31 percent and 19 percent, respectively, so as to enable them to operate on the efficient frontier. For this DMU, the possible reductions of other inputs like, labour days, F&P and organic manure are around 40 percent, 6.17 percent and 28 percent, respectively. These figures represent the potential savings in inputs without reducing output. The same analysis can be carried out for other inefficient STGs.

One of the observations during our survey may also be helpful to understand the situation of inefficient DMUs. We have observed that many of the small tea growers are traditional cultivators who are yet to acquire the requisite technical and entrepreneurial skills for efficient running of their plantation establishments. Because of their low skill for technological adaption, most often they use fertilizer and foliar nutrients more than what is required for optimum level of necessity. It, therefore, enhance the cost substantially without effectively contributing to production.

4.6.7 Potential Average Improvements of Inputs and Output

The following table reports the potential average saving of inputs as well as the potential average improvement in output

Table4.6. Potential average savings and increases

Inputs	% of excess input use
Area	15.25
Irrigation	58.05
Nitro (N)	44.56
Potash (K)	42.82
Phosphate(P)	30.42
FNP	15.25
Organic Manure	48.31
Labour Days	32.27
Green Leaf (output)	142.30

Source: *Field Survey, 2007-08*

The above table reveals that the inefficient STGs had used many inputs more than they ought to use optimally. For instance, many STGs could have reduced N, K and P by 44.56 percent, 42.82 percent and 30.42 percent, respectively. Thus, there is a good deal of opportunity for potential savings in inputs without reducing output. With respect to output, it is found that there is scope for potential improvement by an average 142 percent while keeping the use of inputs unchanged.

4.6.8 Plantation by Holding Sizes and Efficiency Scores

An important dimension of the study is to evaluate the performance of STGs across various holding sizes in terms of TE scores. This study can make reveal whether there is any optimal size of STGs. The composition of the sample of STGs in terms of size of land holding is shown in the following table

Table4.7. Mean TE Score as per land size class of plantation

Plantations by holding sizes	% of Gardens	% share of Efficient Gardens	% Distribution of Efficient Gardens	Mean TE Score (%)	Std. Deviation
below 3 acres	40.32	93.18	46.59	97	0.10
3 to below 6 acres	24.19	65.71	26.14	91	0.15
6 to below 9 acres	15.32	52.63	11.36	85	0.20
9 to below 12 acres	8.06	20.00	2.27	76	0.21
12 to below 15 acres	5.65	57.14	4.55	90	0.15
15 to 25 acres	6.45	88.89	9.09	98	0.03

Source: Field Survey, 2007-08

In the above table, the representative sample is divided into six categories of holding size with the smallest holding size is defined to be ‘below 3 acres’ and the largest holding size is represented by ’15 to 25 acres’. The percentages of efficient gardens out of total gardens corresponding to six different categories are 93.18 percent, 65.17 percent, 52.63 percent, 20 percent, 57.14 percent and 88.89 percent, respectively. Thus, the land holding size under which the maximum percentage of efficient gardens fall among all the categories of land holding happens to be the smallest land holding size of ‘below 3 acres’. The table also shows that in the set of efficient gardens, the percentage shares of gardens under six different categories are 46.59 percent, 26.14 percent, 11.36 percent, 2.27 percent, 4.55 percent and 9.09 percent, respectively. Thus, we see that it is again the land holding size of ‘below 3 acres’ under which we have the highest concentration of efficient gardens in the sample. These results seem to indicate a definite pattern of how the share of efficient gardens changes with the change in size class of land holdings or how the distribution of efficient gardens corresponds to different classes of land holding. It is exemplified that the share of efficient gardens first gradually falls till the holding size ‘9 to below 12 acres’ is reached and starts increasing thereafter for the upper size classes. This relationship is also found to be visible between the variation of mean TE score and the change of land holding size. For the land holding size ‘below 3 acres’, the mean TE score is 97 percent and thereafter, it falls constantly up to the holding size‘9 to below 12 acres’, then it increases successively for the next two upper holding sizes. It appears that the growers under the smallest as well as the upper most holding sizes are most efficient with estimated efficiency scores of 97 percent and 98 percent, respectively. The values of standard deviation of TE scores are found to be relatively smaller, to the tune of 0.10 and 0.03, respectively, for these two extreme land holding sizes. This implies that the variation among the productivity performance of growers under these two land holding size classes are relatively of smaller order as compared to those under other categories of land holding. For the growers belonging to other land holding sizes, the minimum and the maximum TE scores are estimated to be 76 percent and 91 percent, respectively.

The high percentage share of efficiently functioning gardens in the category of below 3 acres seems to give an indication towards why tea growing on small plots of land has become a very significant economic activity in four districts of North Bengal. This result also implies that tea growing on smaller plots of land is equally viable with tea growing on large holdings. There seems to be three-fold reasons for higher productivity and efficiency gains being observable for this land holding size− land suitability, bush productivity and use of family labour to the maximum potential. In terms of land productivity, the reasons for efficiency gains seem to be the soil and climatic conditions that are favourable for tea growing. As noted in chapter3 previously, the majority of the lands utilized for tea plantations are of two categories− high lands with low moisture retaining capabilities and all land located at the estate peripheries. Being largely unsuitable for paddy cultivation, these lands were gradually shifted towards more economic and remunerative agricultural farming practice of tea cultivation. The second source of efficiency gain is plausibly the high bush productivity due to the use of cost-efficient clonal tea saplings which provides higher yield compared to seed stock vis-à-vis young age profile of existing tea bushes in small tea plantations. The third source of higher productivity performance seems to be the use of family labour to the optimal scale. These plantations are usually family managed enterprises and have the potential of using extensively the low-opportunity cost family labour of women, children and aged family members who have little employment opportunity outside their own plantations. Thus, there seems to be enormous efficiency gain in terms of saving of labour cost which constitutes a significant component of total cost of production in small vis-à-vis larger tea plantations alike. It can further be noticed that there have been a lowering down of mean efficiency score as well as a substantial decline in the share of efficient gardens in the total sample in the second land holding size of 3 to below 6 acres. For such gardens, the possible source of inefficiency may be that efficient management of gardens by the family labour becomes increasingly difficult with the increase of size to 3 acres and above.

The highest level of mean TE score (98 percent) along with a large frequency of occurrence of gardens with an efficiency score of 100 percent (89 percent) have been found to exist for the upper most land holding size represented by '15 to 25 acres'. The possible reasons for achieving the highest level of resource use efficiency may be the advantage of potential cost saving by purchasing inputs in bulk quantities along with capturing the benefits of high land productivity and bush productivity.

It follows from the above analysis that there is no existence of any land holding size which could be designated as the optimum class of land holding. The finding of significantly high mean TE score across majority of land holding sizes implies that any STG has the potential of operating efficiently no matter whether he comes under the bottom most land holding size or under the upper most land holding size. irrespective of the land holding size under which he comes. That is to say, the efficient functioning of a STG is absolutely viable irrespective of land holding size. It follows that the causes of inefficiency do not lie with size class of land holding, rather with the non-optimal use of resources.

4.7 Issue of Land Diversion

The estimation of significantly high level of mean TE score as well as the existence of a large percentage of efficient DMUs in the lowest landholding size bracket of below 3 acres seem to have some important bearings on the debate concerning land diversion in the backward agrarian economy of North Bengal. The main point of the debate was that it was largely the non-villagers who had made penetration into small tea growing sector. This had led to encroachment of the sphere of farming activities of the villagers with a peasantry background. The findings of the present efficiency study might help us to gain some useful insights on this debate. First of all, the study indicates successful penetration of the smallholder agricultural farmers of this region in the small tea growing sector as the percentage share of efficiently functioning gardens in the lower categories of land holdings is quite high. This means that they could have acquired requisite skill and efficiency required for taking up tea plantation as an alternative model of commercial agriculture. Initially, this segment of growers had to face the problem of lack of technical and entrepreneurial skills required for establishing tea plantations. This might be the cause of involuntary selling or leasing of portion of their non-cultivable lands to non-peasant class of entrepreneurs in return of assured year-round wage employment in terms of doing work in newly established tea gardens. Gradually, these people having skills in traditional agriculture have come to adapt themselves to tea growing technology by working as tea garden workers. They have eventually decided against selling or leasing out their land and started their own tea plantations. This is a phenomenal change in the entrepreneurial attitude of the rural people that is distinctly visible since mid 1990s. By this time, the extension of periphery of small tea growing sector is predominantly characterized by changeover of farming activities of villagers from low rate of return subsistence farming to more economically rewarding activity of running small tea plantations. Following this development leading to significant penetration of villagers themselves, the incident of land diversion resulting from extension of small tea growing sector does not entirely suggest the encroachment of the sphere of farming activities of the peasant cultivators. Secondly, since most of these plantations are family managed enterprises, the efficient functioning of the gardens by the family seems to provide them with more secured livelihood opportunities in comparison to subsistence farming. With the rapid growth of bought-leaf factories (BLFs), the proliferation process of small growers has got further momentum in terms of an expansion of the size of market for green leaf output. It is to be noted that the small growers either sell the plucked tea leaves to the large tea estates for processing or take them to one of the many BLFs located in proximity to the plantation area. The STGs only grows, whereas the BLFs only manufactures.

4.8 Conclusion

The extension of tea plantation periphery into non-traditional areas is predominantly due to proliferation of small tea growers. The present study is an attempt to estimate technical efficiency of small tea growers in order to make an assessment of their resource use efficiency level. It has been done using DEA. It is revealed from the study that the shares of efficient and inefficient gardens in the sample are 71 percent and 29 percent, respectively. The study further shows that the average resource use efficiency level in tea plantations under small tea growers is significantly high with the mean TE score is estimated to be about 92 percent under the BCCO model. This result also indicates that, on an average, there is a possibility of 8 percent potential yield improvement in this sector. It has also been found that about 75 percent of the STGs within the sample are operating with TE score of 90 percent or above. This is clearly indicative of a remarkably good productivity performance exhibited by this sector. The study finds region-specific variations in the percentage share of efficient gardens to a significant extent. For example, there are two regions, namely, Chopra and Jahuri-Talma, where cent percent STGs are operating on the efficient production frontier. This essentially implies the attainment of maximum potential output from a given set of inputs by the STGs of these regions. By contrast, the regions of Kharibari and Mekhligan are characterized with existence of least percentages of efficient gardens− the figures being 26.67 percent and28.57 percent, respectively. Thus, keeping aside Chopra and Jahuri-Talma, there is ample potential for improving efficiency of STGs in other regions. The result relating to mean TE as per land holding size shows that it takes highest values for the bottom size class (97 percent) and the top most size class (98 percent), though these scores are found to be reasonably high almost across all size classes. This seems to explain why tea growing into non-traditional areas has become a very significant economic activity irrespective of economic and social classes to which the growers belongs. It is equally viable to marginal and small farmers as well as to the owners of business capital on efficiency ground.

The study finds only a relatively smaller proportion (about 29 percent) of technically inefficient STGs in the sample study region. One source of inefficiency has been found to be excess uses of fertilizers and other purchased inputs. The lack of scientific knowledge about proper input application perhaps is the reason for over-use of inputs. The other source of inefficiency has been identified to be the shortfall of quantum of yield relative to the optimal level. The yield gap problem is perhaps attributable to a set of factors determining land suitability which are either in excess of or lower than what is optimally required for tea growing. If this problem is given due attention, the yield gap problem could be mitigated.

To sum up, the study reveals that there is ample potential for improvements in efficiency further by way of realization of higher yield for all sizes of plantations while keeping the usage of inputs unchanged. The alternative avenue for potential efficiency improvement could be input savings without any reduction of yield.