Productivity Improvement of Black Tea Production: A Case Study

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Abstract- Tea plays a major role in Indian economy. As such, productivity improvement of black tea production has been a major concern of the tea industry in the country. The main objectives of the present work are to identify any common trend in productivity changes over time and identify the contributing factors. Data were collected from 10(ten) nos. of tea estates situated at different locations of upper Assam region. These data were regressed by using regression software (Minitab-14) to develop the correlation model between total productivity and partial productivity. The developed correlation model would definitely contribute to change the management's erroneous mindset for their business to improve productivity. The general factors affecting cost of tea production have been investigated by using Ishikawa's Cause and Effect diagram. Some important improvement methods are suggested in this study.

Keywords - Ishikawa Diagram, Partial Productivity, Productivity Improvement, Regression Analysis, Tea Industry, Total Productivity, Total Factor Productivity.

1. Introduction and Overview

To study about productivity and its improvement of a tea industry and cost associated with tea production, it is necessary to know about its background, culture and present status. Tea production started with tea cultivation. In India, tea cultivation started in the North East part of the country during the British period. Due to favorable climatic condition tea industry started in the state of Assam in 18th century. Suparna [3] analyzed the pattern of discovery of tea in Assam, the first tea growing region of India. Nizara [2] studied the development profile of tea industry in Assam in term of production and growth rate of area. A brief account of present status of tea industry along with the objectives and methodology of the study undertaken in this project work has been presented in this paper.

Tea is an aromatic beverage commonly prepared by pouring hot or boiling water over cured leaves of the tea plant, Camellia Sinensis. After water, tea is the most widely consumed beverage in the world. Tea has a cooling, slightly bitter, and astringent flavour that many people enjoy. Tea is also the 'State Drink' of Assam according to the ASSOCHAM report released in December, 2011[10].

2. Objective of the Present Study

1. To study the productivity changes over the years in different tea estates of Assam.
2. To identify the major contributing factor on productivity.
3. To propose suitable productivity model(s).

3. Methodology and Tools/Techniques Used

The study has been carried out with the following steps:

(a) Data collection in designed format from different tea estates (in the upper Assam) regarding their labour input, capital input, materials input, energy input, welfare input, miscellaneous input, total tea made, selling price etc.

(b) Personal interview and observations made during field visits and also secondary data collected from literature survey at the Research Centre.

(c) Identification of the factors affecting cost of black tea production using Ishikawa's Cause and Effect diagram.

(d) Productivity analysis of black tea production in different tea estates carried out and result comparison.

(e) A multivariate study & regression analysis with the help of statistical software (Minitab-14).

4. Field Visit and Data Collection

Ten different tea estates in upper Assam district were visited for the study. The last three years' data were collected in designed format from those tea estates of upper Assam district regarding their

labour input, capital input, material input, energy input, welfare input, misc. input, total tea made, selling price etc. These data are analyzed using Regression software to develop the correlation model between total productivity and partial productivity. This partial productivity includes labour, capital, material, energy, welfare and miscellaneous productivities. Productivity analyses of black tea production in different tea estates are compared. Identify factors affecting cost of black tea production.

5. Manufacturing Process of Black Tea

For manufacture of black teas, the shoots pass through the following six distinct phases of processing:

- Leaf harvest and transport to factory
- Withering-physical & chemical
- Cell maceration
- Oxidation
- Drying
- Shorting and packaging

The manufacturing processes have many inputs and output factors, which affects productivity.

1. Human input: Administrative staff, professional, field and factory workers etc.
2. Capital input: i) Fixed: Land, building, machinery, tools and equipment, others. ii) Working: Cash, inventory, account, transportation etc.
3. Material input: Raw material (own and purchased), purchased parts and others.
4. Power or Energy input: Electricity, fuels, oils etc.
5. Welfare and subsidized ration input: Health, education, entertainment, safety, subsidized ration for labor and staff, etc.
6. Miscellaneous: Administrative expenses, repair and maintenance, insurance, others.

Such output factors are-

1. Quality finished product for sale, other incomes.

6. Factors Affecting Cost of Black Tea Production

The different possible causes of rising cost of production of tea have been presented with the Cause and Effect diagram as shown in the Figure 6.1. The diagram is used to explore all the real causes or inputs that results in a single effects or output.

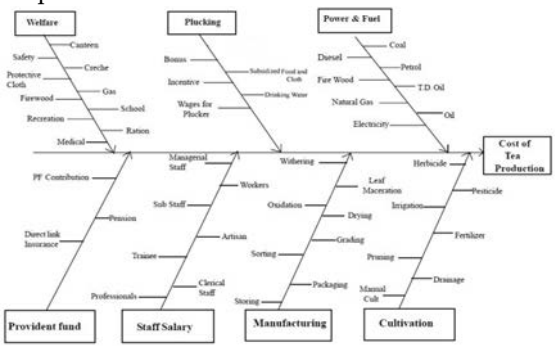

Fig. 1: Ishikawa diagram showing the factors affecting cost of tea production.

From the diagram it is seen that the following are the main input factors that affect the cost of tea production.

1. Human input: Managers, staff, workers, trainee, clerical staff, medical, artisan, etc.
2. Capital input: i) Manufacturing [fixed and working] ii) Cultivation [herbicide, pesticide, drainage, irrigation, pruning etc.]
3. Material input: Raw material (green leaf), manure (organic and chemical), nylon bag, water, etc.
4. Energy and fuel input: Electricity, fuels (petrol, diesel, gas, coal, oil, T.D oil) etc.
5. Welfare input: Medical, school, recreation, ration, maternity benefit, crèche, cooking fuel, canteen, protective clothing, provident fund and pension etc.

7. Productivity Measures

The following productivity measures have been considered in the study.

A. Total Productivity Measure (TPM)

Total Productivity is the ratio of total output to the sum of all input factors.

$$\text{Total Productivity} = \frac{\text{Total Tangible Output}}{\text{Total Tangible Input}}$$

Where,

Total tangible output = Value of finished goods produced + value of partial units produced + dividends from securities + interest from bonds + other incomes.

Total tangible input = Value of (human + capital + material + energy + welfare + other expenses)

B. Partial Productivity Measures (PPM)

Partial productivity is the ratio of output to one class of input. For example, labour productivity, capital productivity etc.

$$\text{Partial Productivity} = \frac{\text{Total Output}}{\text{Individual Input}}$$

C. Total-Factor Productivity

Total-factor productivity is the ratio of net output to the sum of associated labour and capital (factor) inputs.

$$\text{Total-Factor Productivity} = \frac{\text{Net Output}}{\text{(Labor+Capital) Input}}$$

Data collected in terms of output (amount and price) and inputs in term of labour, capital, material, energy, welfare and miscellaneous expressed in monetary value for ten tea gardens are shown in table 1,2,3,4,5,6,7,8,9and10.

Table 1: Total Output and Inputs from 2011 to 2014 (Tea Estate 1)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made(Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	1600250	112.25	309.79	130.25	190.47	223.14	168.5	169.35	1191.50
2012-13	1583354	130.14	306.00	143.75	198.42	235.63	185.5	178.63	1247.93
2013-14	1448391	134.25	338.76	155.18	205.34	245.67	196.3	187.50	1328.75

Table 2: Total Output and Inputs from 2011 to 2014 (Tea Estate 2)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	193945	85.25	29.58	15.25	20.46	27.37	20.50	21.64	134.80
2012-13	207025	100.15	30.04	17.46	28.25	25.38	23.63	22.82	147.58
2013-14	239550	110.40	35.69	20.40	25.26	32.64	24.50	25.74	164.23

Table 3: Total Output and Inputs from 2011 to 2014 (Tea Estate 3)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	837274	130.00	160.07	110.84	124.95	105.48	90.50	94.75	686.59
2012-13	830737	133.00	158.06	115.40	132.25	118.75	95.50	115.84	735.80
2013-14	764283	140.00	140.87	120.25	130.72	114.94	104.50	110.65	721.93

Table 4: Total Output and Inputs from 2011 to 2014 (Tea Estate 4)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	1731574	139.00	323.94	250.85	278.47	259.25	185.63	214.59	1512.73
2012-13	1956398	142.00	350.45	261.32	290.65	262.67	205.01	230.45	1600.55
2013-14	2042850	149.00	374.34	275.47	306.25	247.63	225.3	243.15	1672.14

Table 5: Total Output and Inputs from 2011 to 2014 (Tea Estate 5)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	997849	138.00	180.41	105.45	145.72	120.50	115.65	113.24	780.97
2012-13	1067634	141.00	181.38	128.68	153.25	128.54	120.35	116.40	828.60
2013-14	972308	147.00	169.81	130.40	160.35	132.86	128.25	126.50	848.17

Table 6: Total Output and Inputs from 2011 to 2014 (Tea Estate 6)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	3467102	138.00	763.17	501.33	550.87	504.02	428.26	384.95	3132.60
2012-13	3254605	141.00	756.73	500.45	575.23	510.67	433.50	395.42	3172.00
2013-14	3342250	147.00	823.86	516.32	590.25	521.64	442.17	408.75	3302.99

Table 7: Total Output and Inputs from 2011 to 2014 (Tea Estate 7)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	2835160	137.00	625.07	415.75	484.62	421.36	327.15	325.47	2599.42
2012-13	2923650	140.00	682.95	422.87	494.35	430.75	335.46	340.50	2706.88
2013-14	2987350	146.00	737.04	430.72	506.38	443.15	345.40	350.65	2813.34

Table 8: Total Output and Inputs from 2011 to 2014 (Tea Estate 8)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	1285470	136.00	263.44	165.84	197.35	149.48	135.65	138.76	1050.52
2012-13	1348250	139.00	282.49	175.72	198.25	159.46	140.50	152.65	1109.07
2013-14	1375460	142.00	302.11	185.87	215.35	176.68	154.50	170.45	1204.96

Table 9: Total Output and Inputs from 2011 to 2014 (Tea Estate 9)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	1437650	136.00	282.74	200.48	235.75	196.83	167.50	180.35	1263.65
2012-13	1489350	139.00	319.67	210.25	255.47	214.65	180.72	200.56	1381.32
2013-14	1475530	142.00	334.69	228.76	270.35	225.27	190.51	214.68	1464.26

Table 10: Total Output and Inputs from 2011 to 2014 (Tea Estate 10)

Year	Output per year		Input (In Lac) per year (Rs)						
	Tea made (Kg)	Selling Price (Rs)	Labour	Capital	Material	Energy	Welfare	Misc.	Total Input
2011-12	975430	139.00	191.44	120.65	142.57	110.48	105.20	116.55	786.89
2012-13	987625	142.00	206.61	132.87	150.64	126.25	110.37	122.45	849.19
2013-14	995376	146.00	221.70	135.75	159.46	133.58	115.63	135.84	901.96

Total productivity and total-factor productivity are calculated and tabulated for each garden are shown in the following table 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9 and 6.10 respectively based on input data given in the previous chapter.

Table 11: Total Productivity and Total-Factor Productivity from 2011 to 2014 (Tea Estate 1)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{\text{Input}}$	Labour + Capital input	Total-factor productivity
2011-12	1191.50	1796.28	1.51	440.04	4.08
2012-13	1247.93	2060.58	1.65	449.75	4.58
2013-14	1328.75	1944.46	1.46	493.94	3.94

Table 12: Total Productivity and Total-Factor Productivity from 2011 to 2014 (Tea Estate 2)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{\text{Input}}$	Labour + Capital input	Total-factor productivity
2011-12	134.08	165.33	1.23	44.83	3.69
2012-13	147.58	207.34	1.40	47.50	4.37
2013-14	164.23	264.46	1.61	56.09	4.71

Table 13: Total Productivity and Total-Factor Productivity from 2011 to 2014 (Tea Estate 3)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{\text{Input}}$	Labour + Capital input	Total-factor productivity
2011-12	686.59	1088.46	1.59	270.91	4.02
2012-13	735.80	1104.88	1.50	273.46	4.04
2013-14	721.94	1070.00	1.48	261.12	4.10

Table 14: Total Productivity and Total-Factor Productivity from 2011 to 2014 (Tea Estate 4)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{\text{Input}}$	Labour + Capital input	Total-factor productivity
2011-12	1512.73	2406.89	1.60	574.79	4.19
2012-13	1600.55	2778.09	1.74	611.77	4.20
2013-14	1672.14	3043.85	1.82	649.81	4.68

Table 15: Total Productivity and Total-Factor Productivity from 2011 to 2014 (Tea Estate 5)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{Input}$	Labour + Capital input	Total-factor productivity
2011-12	780.97	1377.03	1.76	285.86	4.82
2012-13	828.60	1505.36	1.82	310.06	4.86
2013-14	848.17	1429.29	1.70	290.21	4.93

Table 16: Total Productivity and Total-Factor Productivity from 2011 to 2014(Tea Estate 6)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{Input}$	Labour + Capital input	Total-factor productivity
2011-12	3132.60	4784.60	1.53	1264.50	3.78
2012-13	3172.00	4588.99	1.45	1257.18	3.65
2013-14	3302.99	4913.11	1.49	1340.18	3.67

Table 17: Total Productivity and Total-Factor Productivity from 2011 to 2014(Tea Estate 7)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{Input}$	Labour + Capital input	Total-factor productivity
2011-12	2599.42	3884.17	1.49	1040.82	3.73
2012-13	2706.88	4093.11	1.51	1105.82	3.70
2013-14	2813.34	4361.53	1.55	1167.76	3.73

Table 18: Total Productivity and Total-Factor Productivity from 2011 to 2014 (Tea Estate 8)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{Input}$	Labour + Capital input	Total-factor productivity
2011-12	1050.52	1748.24	1.66	429.28	4.07
2012-13	1109.07	1874.07	1.69	458.21	4.09
2013-14	1204.96	1953.15	1.62	487.98	4.00

Table 19: Total Productivity and Total-Factor Productivity from 2011 to 2014(Tea Estate 9)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{Input}$	Labour + Capital input	Total-factor productivity
2011-12	1263.65	1955.20	1.55	483.22	4.05
2012-13	1381.32	2070.20	1.50	529.92	3.91
2013-14	1464.26	2095.25	1.43	563.45	3.72

Table 20: Total Productivity and Total-Factor Productivity from 2011to 2014(TeaEstate10)

Year	Total input (In Lac)	Total output (In Lac)	Total productivity $= \frac{Output}{Input}$	Labour + Capital input	Total-factor productivity
2011-12	786.89	1355.85	1.72	312.09	4.34
2012-13	849.19	1402.43	1.65	339.48	4.13
2013-14	901.96	1453.25	1.61	357.45	4.07

A. Total Productivity Comparison Chart

Graphical representations of total productivities of ten different tea estates of upper Assam district for the last three years are shown in the Figure 2.

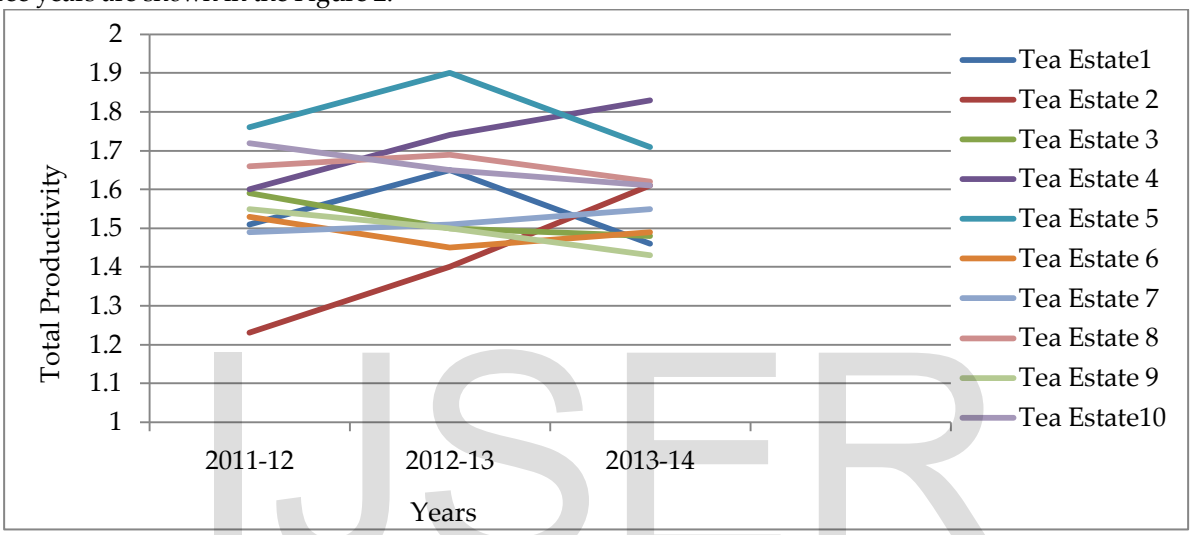

Fig. 2: Graphical representations of total productivities of ten different tea estates of upper Assam

Total Productivity Comparison Bar

Bar diagram of total productivities of ten different tea estates of upper Assam district for the last three years are shown in the Figure 3.

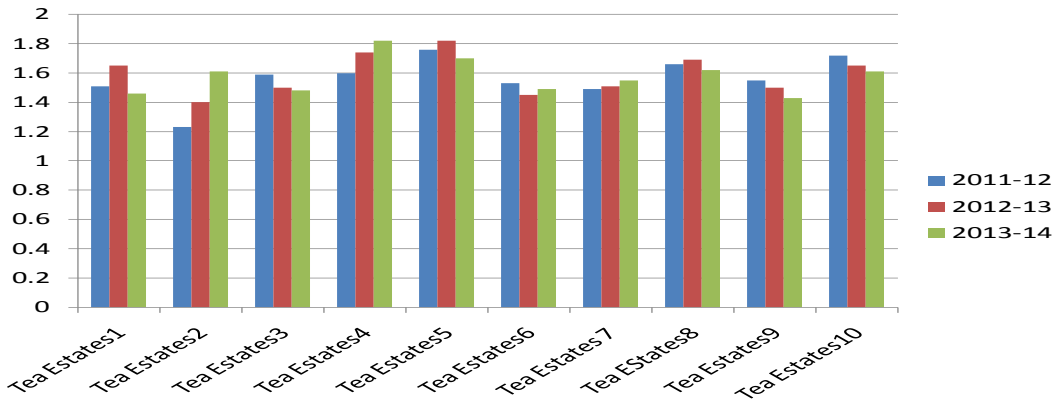

Fig. 3: Bar diagram of total productivities of ten different tea estates of upper Assam

8. Results and Discussion

A. Total Productivity Comparison

In tea estates 1 & 5, their total productivity increased in the year 2011-12 and 2012-13 but decreased in the year 2013-14 due to their increase in labour and material cost.

The results of total productivity in the tea estate 1, as shown in the Table 1, is seen that the total productivity was more in the year 2012-2013. Again evaluating data from tea estates 2, 4 and 7 as shown in the Table 2, 4 and 7 it is seen that total productivity increased gradually from 2011 to 2014.

The total productivity increased due to increase in inputs resulting in a very large increase in output.

Evaluating data from tea estates 3, 9 and 10 as shown in the Table 3, 9 and 10 it is also seen that total productivity decreased from 2011 to 2014 because of their increase in production cost.

The total productivity decreased as the inputs increased but the output is not increasing proportionately.

Total productivity measure is easy to calculate and gives a more accurate representation of the total picture of the tea estates because it is easily related to total cost, considering all quantifiable inputs and outputs.

Graphical representations and bar diagram of total productivities of ten different tea estates are also shown in the fig. 2 & 3.

B. Partial Productivity

For regression equation, total productivity and different partial productivities are entered in the regression software (Minitab-14). The partial productivity measure is a tool to pinpoint improvement considering only one input factor at a time. For each input factor partial productivity is computed to get different productivity indices like labour productivity index, capital productivity index, etc.

Among the partial productivity measures, labour productivity index is the most common and popular at the national level.

C. Total - Factor Productivity

In the tea estates 6 & 7, total-factor productivity is less due to their increased in labour and capital expenditure. Though total factor productivity is a value added approach, it is difficult to relate production efficiency by considering only labour and capital inputs.

As compared to partial productivity, total factor productivity also depends upon labor and capital input, therefore, it can be improved if labour and capital expenditure can be reduced.

9. The Relation between Total Productivity and Partial Productivity

Regression software (MINITAB-14) is used to develop the correlation model between total productivity and partial productivity.

Total productivity and partial productivity are related through the regression equation as given below.

PRODUCTIVITY = - 0.0146 + 0.0585 L + 0.0168 C + 0.0308 M + 0.0283 E + 0.0187 W + 0.0220 MI..... (1)

R-Sq. = 99.9% R-Sq. (adj.) = 99.9%

Where,

L- Labor, C- Capital, M-Material, E-Energy, W-Welfare, MI-Miscellaneous.

From the above equation (1) it is seen that the coefficient of labor (L) and material (M) are more. So the labor and material are the key factors for the productivity change and capital has the least effect. Intercept constant can be positive and may be negative. It is the starting point of the equation.

A. Residuals versus the Order of the Data

Residual means deviation or difference between actual value and estimated value. Sum of all residuals is zero.

The figure 4 shows no specific graph pattern by residual in respect of data, it is only with observation order.

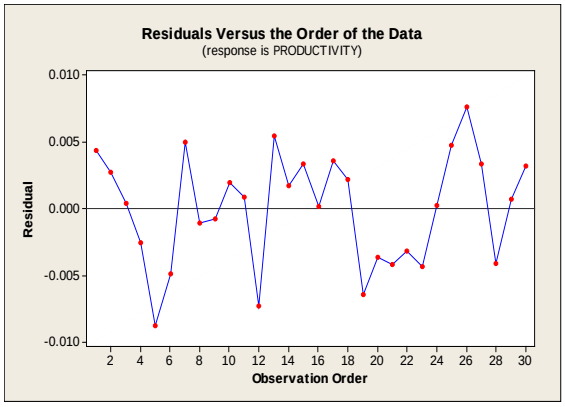

Fig.4: Residuals vs. Order for Productivity

B. Histogram of the Residuals

The figure 5 shows that the Frequency decreases as residual increases.

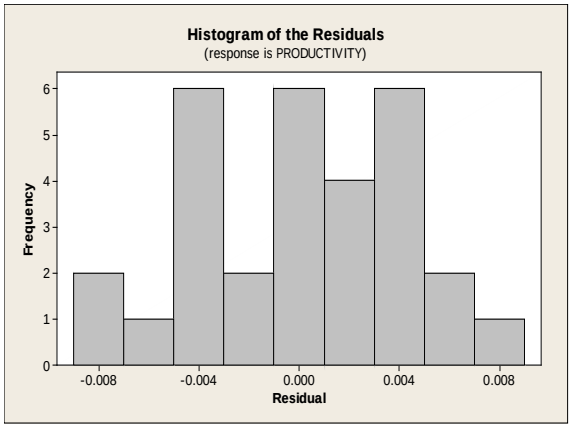

Fig.5: Residual Histogram for Productivity

C. Normal probability plot of the residuals

The fig. 6 shows the best fitted curve. The assumption is normality.

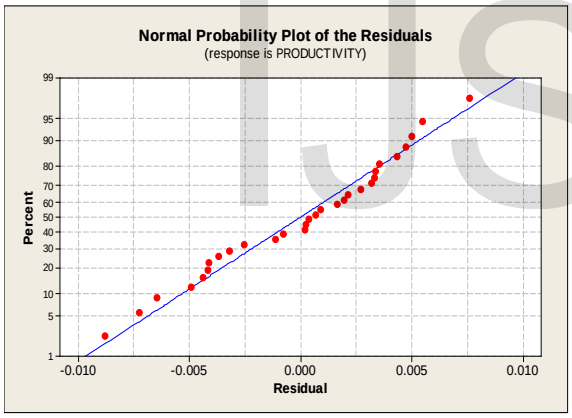

Fig.6: Norm plot of Residuals for Productivity

10. Productivity Improvement

Productivity improvement does not mean just doing things better. More importantly, it is doing right things better. It is a process of change. To improve productivity it is therefore necessary to manage change.

A. Improving Labour Productivity

Labour productivity may be improved by -

- Improving working conditions- lighting, ventilation, noise(music), temperature, work times
- Using appropriate and better tools
- Ergonomics and better work station layout
- Improving factory, stores & office layout
- Improving the method/process
- Improving the nutritional status of the worker
- Improving industrial housekeeping (5s) and safety
- Improving welfare facilities and worker motivation
- Using the brains of the workers by
  - Quality Circles
  - Staff Suggestion Schemes
  - Kaizen System(Seiri-sort, Seiton-Set-order, Seiso-clean-up-Shine Seiketsu-standardize, Shitsuke-Sustain-Training & Discipline)
  - Self-Directed Work Teams
  - 3 Mu –Muda (Waste), Muri-(Strain), Mura(Discrepancy)

B. Improving Capital Productivity

Capital productivity may be improved by -

- Implementing TQM
- Reducing Working capital
- Reducing floor space
- Utilizing machinery & equipment better, etc.

C. Improving Material Productivity

Material productivity may be improved by

- Cheaper material
- Alternative material
- Cheaper sources
- Better utilization

D. Improving Energy Productivity

Energy productivity may be improved by -

- Improving power factor
- Reducing wastage
- Changing processes for less heating
- Studying working procedures, etc.

E. Implementation for Better Productivity

The following may be implemented for better productivity -

- A Kaizen culture
- Staff suggestion scheme
- Small group activities
- An environment which appreciates productivity
- Convince the work force of benefits

11. Conclusions

From productivity analysis and regression equation it is seen that labour and material productivity has the major influence on total

productivity hence to increase total productivity there must be increased in labour and material productivity by reducing labour and material cost to the possible extent. It is observed from the result and discussion that energy and welfare also take major role among the factors of tea production.

This regression equation has been developed on the background of C.T.C method of tea manufacture processing of the tea estates under study. Here the total productivity is dependent variable and partial productivity is independent variable.

The study identifies the various factors affecting cost of black tea production. From productivity analysis and field visit (data collected from different tea estates) it is observed that the cost associated with labour, material, energy, and welfare takes major role among the factors of tea production. The cost of labour and material can be reduced or controlled to some extent by adopting the measures such as proper design of tea industry, by using automatic machinery and equipment, by using organic manure instead of chemical fertilizer, etc.

The welfare cost can be considered as a social cost, a portion of which may be shared by the government. The cost of manure can be reduced to a great extent by organic farming on tea plantation level which eliminates the cost of chemical fertilizers and pesticides without affecting yield and quality of tea. Marginal areas that are potentially low yielding can go for alternative planting like 'Jatropha' or *'Mesua Ferrea'* planting, which has global demand for producing bio-diesel.

In the project work, ten different tea estates at different locations of upper Assam were taken for the productivity analysis and to establish a relationship between total productivity and partial productivity. Last three years data were taken for productivity analysis and to identify the different factors affecting productivity in general in the present work. The findings of the study will help the tea estates in improving productivity and also will motivate further study in this field.

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13. References

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