IMPLEMENTATION OF TOTAL QUALITY MANAGEMENT (TQM) PRINCIPLES IN TEA INDUSTRY: INVESTIGATION AND CRITICAL ANALYSIS

Thesis
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Dedicated to

my father-in-law Late Bijoyananda Baruah....

CERTIFICATE

This is to certify that, the thesis entitled **"Implementation of Total Quality Management (TQM) Principles in Tea Industry : Investigation and Critical Analysis"**, which is being submitted to the Tezpur University, Tezpur for the award of the degree of **Doctor of Philosophy** by **Mr. Plabon Kakoti**, is a record of bona-fide research work carried out by him, under our guidance. In our opinion, the thesis has reached the standard of fulfilling the requirements and is worthy of award of the Degree. The results embodied in this thesis, have not been submitted elsewhere for the award of any other Degree or Diploma.

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Abstract

The recent trend in Indian Tea industry depicts a disturbing decline in terms of price, and quantity of export. Substantial increase in labour wages, garden operating expenses, statutory liabilities and general inflation have considerably eroded profit margins for the gardens.

In the context of present crisis of Tea Industry, the only answer to enhance demand, stabilize growth and maintain it, is "Relentless Improvement in Tea Quality" along with "Never ending reduction in unnecessary cost". In other words: - Continuous Improvement (CI) in every sub-system of Tea Industry is a must for its survival.

This thesis makes an attempt to identify and present an analysis of the factors affecting Quality of tea by classifying the factors into garden controllable and garden un-controllable factors. The thesis also describes some of the key areas of production process where continuous improvement is needed for sustained growth of tea industry of Assam by implementing the concept of Total Quality Management (TQM).

The unique aspects of the thesis include development of an assessment tool for total quality culture prevailing in a tea garden, which helps the management in initializing the TQM/CI process. The operational framework for the implementation of TQM in the system is arrived at, by the quantitative assessment of quality level of different subsystems, to set up the CI/TQM. In addition, an Information System named "Tea Information System (TIS)", which incorporates the assessment tool and provides information on – Assam and Indian Tea Industry, tea manufacturing process, tea facts, different grades of tea, the culture of tea tribes of Assam, tea vocabulary, standards in tea along with a well covered tea directory covering 498 companies and 722 tea gardens has been developed as a knowledge base for tea plantation and in quality planning to assist the tea management professionals.

Key words: Total Quality Management, Continuous Improvement, Tea Quality, Quality Culture, Total Quality Management Indicator, Performance Indicator

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Abbreviations	Description
TQM	Total Quality Management
CI	Continuous Improvement
TQMI	Total Quality Management Indicator
PI	Performance Indicator
SPI	Sector Performance Indicator
CTC	Crushing Tearing and Curling
FBD	Fluidized Bed Dryer
VFBD	Vibro-Fluidized Bed Dryer
ATPA	Assam Tea Planters' Association
TRA	Tea Research Association of India

Variables	Description
SPIG	Sector Performance Indicator for Garden Sector
SPIPROC	Sector Performance Indicator for Processing Sector
SPIENG	Sector Performance Indicator for Energy Sector
SPIHR	Sector Performance Indicator for Human Resource Sector
SPIMAINT	Sector Performance Indicator for Maintenance Sector
SPIWEL	Sector Performance Indicator for Welfare Sector
SPIMAN	Sector Performance Indicator for Management Sector
BS	Base Score
PDN	Total Production of the Garden in the Computing Period (Kg)
PRA	Average Price Realized in Auction by the Garden Tea in the Computing Period
AREA	Total Area of the Garden
PPH	Production Per Unit Area
TOTEXPENSE	Total Expenses Incurred by the Garden in the Computing Period

EFERT	Cost of Fertilizer Used in the Computing Period
EPP	Expenses Incurred in Plant Protection in the Computing Period
EWEED	Cost of Weedicides Used in the Computing Period
EPEST	Cost of Pesticides Used in the Computing Period
ENUR	Expenses in Nursery Activities in the Computing Period
EFIE	Other Expenses in Field Improvement in the Computing Period
ERAE	Expenses Incurred in Field Rejuvenation Activities in the Computing Period
TOTG	Total Expenses on Garden Sector in the Computing Period
RGETTE	Ratio of TOTG to TOTEXPENSE
AGLI	Total Green Leaf Plucked during the Computing Period
ADM	Average Quantity of all Type of Tea in the Dry Mouth.
RCON	Leaf to Made Tea Conversion Ratio
EEF	Total Expenses on Electrical Energy in Factory for the Computing Period
EEB	Total Expenses on Electrical Energy in Bunglows for the Computing Period
EESL	Total Expenses of Electrical Energy in Street Lighting for the Computing Period
EEOP	Total Expenses of Electrical Energy in other Places of Estate Control for the Computing Period
FEVE	Expenses on Fuel of the Vehicles under Estate Control for the Computing Period
FEDG	Total Expenses of Fuel for the Auxiliary Power Supply (DG set/ Turbine) for the Computing Period
FED	Total Expenses of Fuel for the Dryer for the Computing Period
TOTEE	Total Expenses on Electrical Energy for the Computing Period
TOTF	Total Expenses on Fuel for the Computing Period
TOTENG	Total Expenses on Energy Sector for the Computing Period
ETP	Energy Consumption per Kg of Tea Production
EPE	Amount Spent on Permanent Employees on Salary/wage Head for the Computing Period
ETE	Amount Spent on Temporary Employees on Salary/Wage Head for the Computing Period
BON	Bonus Paid during the Computing Period
MBM	Amount Spent on Management Staff other than Salary during the Computing Period
MED	Medical Expenses for Referral Treatment for All Employees in Pay-Roll for the Computing Period
OHS	Overhead Expenses on Salary for the Computing Period
TEHS	Total Expenses on Human Resource Sector for the Computing Period
TEHSPK	Rupees per Kg of Tea Production in Human Resource Sector (This will indicate the investment on employees to produce 1 kg of made tea)
EMR	Expenses Incurred on Maintenance of Roads within the Garden in the Computing Period
EMF	Expenses Incurred on Maintenance of Factory Building in the Computing Period
EMQ	Expenses Incurred on Maintenance of Residential Quarters in the Computing Period

EOT	Expenses Incurred on Maintenance of Transport Vehicles of the Garden in the Computing Period
EIF	Expenses Incurred on Maintenance of all other Infra-Structure like Hospital, *Clubs, Crèche, Playgrounds, Community Hall, Water Supply System Etc. of* the Garden in the Computing Period
ECP	Amount Paid as 'Compensation' for Accidents within/outside the Factory in the Computing Period
TMAIN	Total Expenses on Maintenance Sector in the Computing Period
PEMAIN	Ratio of Total Expenses on Maintenance Sector in the Computing Period to the Total Expenses Incurred by the Garden in the Computing Period
WEMP	Amount Spent for Mandatory Employee Welfare activities in the Computing Period
WSOS	Amount Spent for Ex-Garden Welfare Activities in the Computing Period
EAME	Expenses Incurred in Setting & Upgrading New Welfare Amenities of the Garden in the Computing Period (Non-Mandatory)
EHOS	Total Operating Expenses of the Garden Hospital in the Computing Period
EWEL	Total Expenses Under Welfare Head in the Computing Period
RWTE	Ratio of Actual Total Expenses Under Welfare Head to Total Expenditure
ALTW	Altitude
LTHW	Average length of the day
RFNDW	*Average rainfall during November – December*
RFJMW	Average rainfall during January - March
ETMAXW	Maximum environmental temperature
ETMINW	Minimum environmental temperature
CW	Organic Carbon Content of Soil
LOCGW	Location of the Garden
LOCHOW	Location of the Head Office of the Garden
PHW	Soil pH
BDW	Soil Bulk Density
LANDW	Land profile of the Garden

Chapter: I

Introduction and Overview

1.1 The Tea Plantation

The tea plant, first classified by Linnaeus as ***Thea Sinensis*** and later named ***Camellia Sinensis,*** has its origin or its center of dispersal in Southeast China near the sources of the Irrawaddy River. Tea has widely spread from the main original area in Southeast Asia, with its traditional peasant cultivation, into many tropical and sub-tropical regions. In these new producing areas, tea developed into an important plantation industry during the 19th century.

The traditional major tea producing countries in Southeast Asia are India, Bangladesh, Sri-Lanka, Japan and Indonesia. Later, in the 19th century tea cultivation spreaded beyond Asia to other places like Russian Caucasus and East-Africa.

The saga of commercial development of tea in India is both awe-inspiring and fascinating. The search for tea in Assam was started by East-India Company as an alternate source of supply to the U.K, which till then was mainly dependent on China. It was thought by the ***Tea Committee*** established by the Governor General in 1834 that the tea plant was indeed indigenous to Assam, especially in the upper reaches (Dutta, A.K.; 1992). However, the most authentic source of information on existence of tea came from Major Robert Bruce who discovered tea plants in Upper Assam. This discovery virtually laid the foundation of tea industry in India (Griffiths, S.P, 1977). It is of interest that Dewan Maniram Dutta Barua, who was a minister to the last Ahom King of Assam, was aware of existence of tea plants, which grew in the territories inhabited by the Singpho tribes in Assam, though it was not clear if these plants primarily originated there.

Major production centers came up in Darjeeling and Cachar by 1856, in the Terai in 1862, and in the Dooars in 1874. This was followed by rapid growth in the Nilgiris, Travancore-wynaad and the Anamalais in South India. From the modest beginning in 1839, tea today has come to occupy a leading position in the economic life of India, and commands top positions both in production and export. Tea Industry in India has the preeminence as a foreign exchange earner. This Industry contributes remarkably to the country's GNP (Bora, M.C., 1981). The subtleties and subterfuge as well as the basic concepts and precepts of tea grading were all developed in India. Indeed the world of tea as it is known today had its inspiration and the gamut of tea grading, processing and planting materials used, had one way or other its origin in India. The first commercial effort in organized tea growing was started by the Assam Tea Company in 1839 (Dutta,

A. K., 1992). The pioneering efforts to manufacture tea were made by George Williamson, who literally gave the first direction in the development of tea technology in India, as opposed to traditional method of manufacturing, then practiced in China.

1.2 Importance of Tea Industry in Indian Economy

The importance of tea industry in Indian economy cannot be overemphasized. This agro-based industry is employment intensive and export oriented. It employs more than 1.6 million men and an equal number of women, providing women of India with their single biggest organized employment avenue, and contributes to the welfare of less developed regions and classes. Indirectly it provides employment to more than half a million people (Bordoloi. T.C.; 2004). This industry contributes to the national exchequer by the way of paying substantial central and state taxes, excise duty etc apart from earning huge foreign exchange through export. The tea industry also helps growth of several other industries in the country. The tea industry consumes considerable amount of fertilizers and manure, pesticides, insecticides, weedicides etc., thus creating demands for these products of chemical industries. Before the ban imposed by the Honourable Supreme Court of India on felling and cutting of trees, tea industry was a bulk user of plywood for packing purposes, which had helped the plywood industry to grow along with the tea industry. The huge quantity of tea produced in the remote interior areas requires transportation facilities not only to carry the tea produced from the gardens to the auction market but also for its distribution till it reaches its final customers. The industry uses all modes of transport viz., road, railways, waterways, and airways. While contributing thus to the national economy, the industry provides the common man with a pleasant, non-alcoholic beverage at a very cheap price.

The Indian Tea industry enjoys a few distinctions in the world scene. India is the largest producer and consumer of tea. She has the largest area under tea cultivation and has the distinction of achieving the highest yield per hectare of plantation. From quality point of view the flavour of Darjeeling tea and the liquor from Assam second flush are unique in the world. Indian tea industry has the honour of establishing new facts and developing new technology for the efficient operation of the tea industry as a whole.

The Indian tea industry, inevitably, plays an important role in the world tea scenario as well. Being one of the super powers of tea industry in the world, any change in the Indian Tea industry affects the world tea scene.

Indian Tea Industry therefore demands special attention for maintaining its beneficial contribution towards the national economy.

1.3 The Assam Tea

Assam is located in the North Eastern part of India and is traditionally known for its Industrial backwardness. Assam, blessed with lot of natural resources, is better known in Indian arena for its petroleum resources and in the world arena for its tea. Tea industry in Assam contributes a lot to the growth of the State financially, socially, culturally. Tourists from different parts of India and abroad visit Assam for the existence of this industry in this part. The natural beauty of a well planned garden and the culture of the tea tribe are really a matter of attraction for anyone. Assam is the originator of tea in India and today from quality point of view the liquor of Assam second flush is second to none in the world.

In the production front, out of the total Indian annual tea production of 850 million Kilograms, the Assam Tea Industry has an estimated annual production of 500 million kilograms of tea. The share of tea production in each of the seven tea producing regions of India is shown in Fig 1.1.

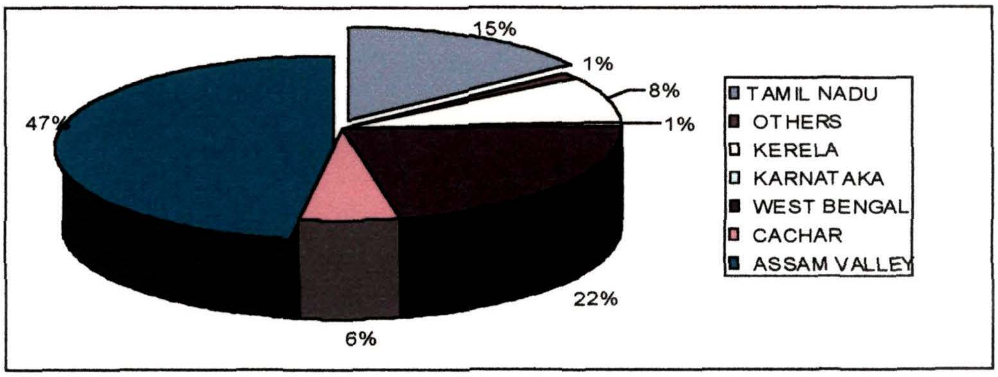


Fig 1.1
State-wise Production of Tea in India

In order to maintain and improve the contributions of this Industry, special continuous attention to this sector is much needed from government and public as well. Table 1.1 shows the progress of Indian Tea Industry during the post independence plan periods.

Table1.1
Progress of Indian Tea Industry During the Plan Periods

Particulars	1st Plan Position as on		% increase over 1951	Average Annual Growth Rate	2nd Plan Position as on		% increase over 1956	Average Annual Growth Rate	3rd Plan Position as on		% increase over 1961	Average Annual Growth Rate
	1/4/1951	31/3/1956			1/4/1956	31/3/1961			1.4.1961	31/3/1966		
Area under cultivation (in thousand hectare)	317	361	1.3	0.3	361	331	-8.3	-1.7	331	345	4.2	0.8
Production (in million Kg)	285	309	8.4	1.7	309	355	14.9	2.9	355	376	5.9	1.2
Average yield (Kg per hectare)	901	963	6.9	1.4	963	1070	11.11	2.2	1070	1089	1.8	0.4
Export of tea (in million Kg)	195	233	19.5	3.9	233	205	-12.0	-2.4	205	197	-3.9	-0.8
Value of export (In crores of Rs)	91	141	54.9	11.0	141	124	-13.3	-2.7	124	157	26.6	5.3
Unit Value (Rupees per Kg)	4.7	6.1	27.7	5.5	6.1	6.0	-1.6	0.3	6.0	8.7	45.0	9.0
% of foreign exchange earnings	17.6	24.5	39.2	NA	24.5	18.5	-24.5	-4.9	18.5	13.5	-27.0	-5.4
Internal consumption (In million Kg)	73	97	32.9	6.6	97	140	44.3	8.9	140	184	31.4	6.3
Central excise revenue from tea (In crore of Rs)	1.4	2.4	71.4	14.3	2.4	10.8	237.5	47.5	10.8	15.6	44.4	8.9

NA: Not Available

Source: "Tea Plantation Industry Between 1850 and 1992, Structural Changes", by Dr. Gangadhar Banerjee, Published by- Lawyer's Book Stall, Guwahati-1996 & Tea Board

Table1.1 (contd.)
Progress of Indian Tea Industry During the Plan Periods (contd.)

Particulars	4th Plan Position as on 1/4/1969*	4th Plan Position as on 31/3/1974	% increase over 1969	Average Annual Growth Rate	5th Plan Position as on 1/4/1974	5th Plan Position as on 31/3/1979**	% increase over 1974	Average Annual Growth Rate	6th Plan Position as on 1.4.1980	6th Plan Position as on 31/3/1985	% increase over 1980	Average Annual Growth Rate
Area under cultivation (in thousand hectare)	353	362	2.5	0.5	362	374	3.3	0.7	374	408	9.1	1.8
Production (in million Kg)	394	489	24	4.8	489	544	11.2	2.2	544	620	14.0	2.8
Average yield (Kg per hectare)	1114	1353	21.5	4.3	1353	1455	7.5	1.5	1455	1523	4.4	0.9
Export of tea (in million Kg)	174	211	21.3	4.3	211	200	-5.2	-1.0	200	217	8.5	1.7
Value of export (In crores of Rs)	121	193	59.5	11.9	193	362	87.6	17.5	362	771	113.0	22.6
Unit Value (Rupees per Kg)	7.1	9.2	29.6	5.9	9.2	18.12	97.8	19.6	18.12	35.5	96.1	19.2
% of foreign exchange earnings	8.8	6.7	-23.9	-4.8	6.7	5.9	-11.9	-2.4	5.9	6.6	11.9	2.4
Internal consumption (In million Kg)	203	260	28.0	5.6	NA	NA	NA	NA	337	431	27.9	5.6
Central excise revenue from tea (In crore of Rs)	13.2	40.0	203.0	40.6	40.0	58.9	47.3	9.5	58.9	56.7	-3.7	-0.7

NA: Not Available
*** There was an Annual Plan for the period of (1966-67 to 1968-69)** **** The 5th five year plan was terminated in 1977-78**
Source: "Tea Plantation Industry Between 1850 and 1992, Structural Changes", by Dr. Gangadhar Banerjee, Published by- Lawyer's Book Stall, Guwahati-1996 & Tea Board

Table1.1 (contd.)

Progress of Indian Tea Industry During the Plan Periods

Particulars	7th Plan Position as on		% increase over 1985	Average Annual Growth Rate	8th Plan Position as on		% increase over 1991	Average Annual Growth Rate	Position as on		% increase over 1951	Average Annual Growth Rate (1951 -1997)
	1/4/1985	31/3/1990			1/4/1991***	31/3/1996			1.4.1951	1/4/1997		
Area under cultivation (in thousand hectare)	408	417	2.2	0.4	420	431	2.6	0.5	317	431	36	0.8
Production (in million Kg)	620	720	16.1	3.2	754	780	3.4	0.7	285	780	173.7	3.8
Average yield (Kg per hectare)	1523	1729	13.5	2.7	1794	1809	0.8	0.2	901	1809	100.8	2.2
Export of tea (in million Kg)	217	209	-3.7	-0.7	201	162	-19.4	-3.9	195	162	-16.9	-0.4
Value of export (In crores of Rs)	771	1104	43.2	8.6	1120	1247	11.3	2.3	91	1247	1270.3	27.6
Unit Value (Rupees per Kg)	35.5	52.8	48.7	9.7	55.15	77.11	39.8	8.0	4.7	77.11	1540.6	33.5
% of foreign exchange earnings	6.6	3.4	-48.5	-9.7	-	-	-	-	17.6	-	-	-
Internal consumption (In million Kg)	431	500	16.0	3.2	-	-	-	-	73	-	-	-
Central excise revenue from tea (In crore of Rs)	56.7	78.9	39.2	7.8	-	-	-	-	1.4	-	-	-

***** Plan was actually delayed by one year**

Source: "Tea Plantation Industry Between 1850 and 1992, Structural Changes", by Dr. Gangadhar Banerjee, Published by- Lawyer's Book Stall, Guwahati-1996 & Tea Board

Table 1.2 shows the area of tea cultivation, volume of production and yield of Indian tea for the century 1850 to 1950.

Table 1.2
Area, Production and Yield of Indian Tea between 1850 and 1950

Particulars	Year		% increase over 1850	Average Annual Growth Rate	Year		% increase over 1890	Average Annual Growth Rate
	1850	1890			1890	1950		
Area under cultivation (in thousand hectare)	0.75	152	20167	504	152	316	108	1.8
Production (in million Kg)	0.097	57	58662	1467	57	278	388	6.5
Average yield (Kg per hectare)	130	373	187	4.7	373	881	136	2.3

Source: "Tea Plantation Industry Between 1850 and 1992, Structural Changes", by Dr. Gangadhar Banerjee, Published by- Lawyer's Book Stall, Guwahati-1996 & Tea Board

1.4 Challenges Faced by the Industry

1.4.1 The Recent Trends of Indian Tea Industry

Over the last few years the Indian tea industry in general is facing a severe crisis. Fig 1.2 shows the auction price of all types of Indian tea (CTC, Orthodox etc) for the period 1997 to 2003 and Fig 1.3 shows the Export of Indian tea for the period. Both the tables reveal that both tea prices and export have come down steadily over the years.

Factors like substantial increase in labour wages, garden operating expenses, statutory liabilities and general inflation have considerably eroded profit margins for the gardens. The erosion of profit has resulted in inability of the tea-management to pay adequate bonus to the employees of the gardens. Such situation leads to abnormal employee-management relationship and in the year 2003 a number of tragic incidents took place in some of the Company-owned and private tea gardens of Assam.

While the sale volume and domestic consumption of Indian tea is falling, the fact of concern is that India's market is now flooded with tea produced in Sri Lanka, Taiwan, etc. (Assam Tribune, May 24th 2004). Indian tea is facing tough competition both in the domestic and the foreign market.

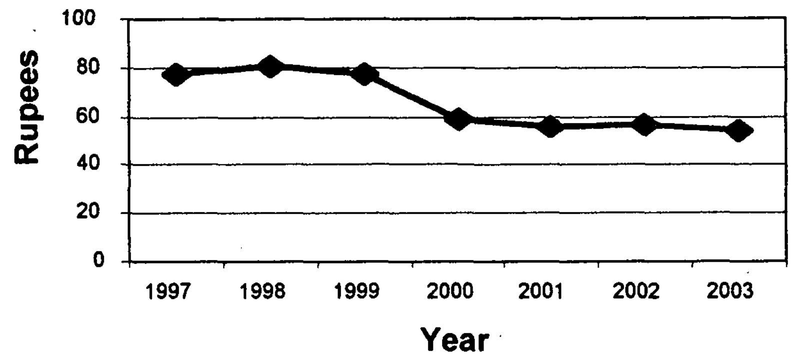


Fig 1.2
Average Auction Price of Indian Tea

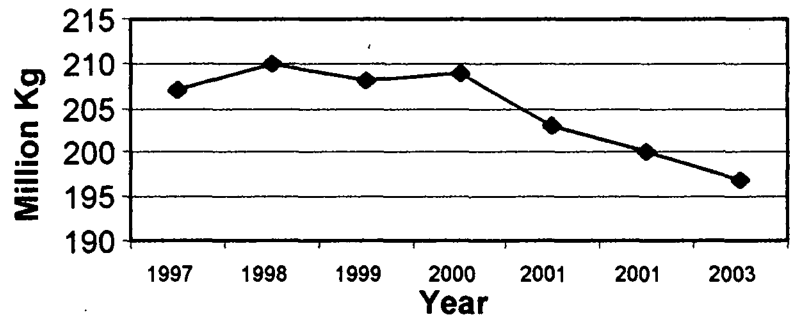


Fig. 1.3
Export of Indian Tea

Thus the recent trend in Indian Tea industry shows a disturbing decline in terms of price and volume of export. The central problem being faced is to meet the future demand in a manner, which will ensure remunerative prices for the industry, while at the same time the vast domestic customers get quality tea at a reasonable price. Besides, the export market has to be maintained, if not expanded.

Industry circles point out that while the price of tea at the retail level has been consistently growing, reflecting an increase in demand, prices at tea auctions (the primary market), has been falling for the last five years. This phenomenon needs serious attention.

Table 1.3 shows Center wise Quantity of Tea Sold (million Kg) and their average Price (Rs) during January/June & April/June 2002

Table 1.3
Category-wise Quantity Sold (mkg) and Average Price (Rs) January /June &April /June 2002

	Jan/June 02		Jan/June 01		April/June 02		April/June 01	
KOLKATA	Kg	Average	Kg	Average	Kg	Average	Kg	Average
CTC leaf	23.67	60.53	20.54	79.79	7.83	68.54	6.27	80.32
Orthodox leaf	6.82	65.55	7.39	69.55	1.99	84.10	1.83	94.42
Darjeeling	2.00	131.13	1.50	168.94	1.05	170.44	0.83	206.69
All Dust	11.33	48.49	10.18	72.75	3.31	57.82	2.39	75.22
Total	43.82	61.42	39.61	79.45	14.18	75.77	11.32	90.79
GUWAHATI								
CTC leaf	28.77	58.01	29.94	78.53	9.61	70.21	13.89	75.02
Orthodox leaf	14.21	48.92	14.17	71.34	4.36	64.91	5.22	74.05
All Dust	0.27	48.92	0.22	52.66	0.09	56.28	0.09	75.10
Total	43.25	54.97	44.33	76.10	14.06	68.48	19.20	74.76
SILIGURI								
CTC leaf	21.14	55.36	19.27	73.72	10.73	9.78	9.78	74.30
Darjeeling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All Dust	3.90	48.31	4.35	63.07	1.76	56.96	1.88	66.93
Total	25.04	54.26	23.62	71.76	12.49	62.57	11.66	73.11
NORTH INDIA Total	112.11	57.33	107.56	76.38	40.73	69.20	42.18	78.60
KOCHI								
CTC leaf	1.79	34.72	3.05	44.27	0.86	34.86	1.58	41.20
Orthodox leaf	6.62	50.39	8.44	54.65	3.26	49.82	4.19	53.44
All Dust	19.82	48.21	20.76	53.60	10.36	48.28	10.94	50.36
Total	28.23	47.87	32.25	52.99	14.48	47.83	16.71	50.27
COIMBATORE								
CTC leaf	2.36	35.51	6.00	43.99	2.36	35.51	3.36	40.00
Orthodox leaf	1.08	47.86	2.40	52.95	1.08	47.86	1.36	52.00
All Dust	3.07	44.61	4.13	47.95	3.07	44.61	2.0	44.44
Total	6.51	41.85	12.53	47.01	6.51	41.85	6.72	43.92
COONOOR								
CTC leaf	20.03	36.57	28.15	45.32	9.22	36.79	17.18	42.08
Orthodox leaf	1.29	44.82	0.83	46.33	0.73	45.53	0.49	45.37
All Dust	6.48	37.94	7.43	42.64	3.24	37.62	3.96	38.62
Total	27.80	37.27	36.41	44.80	13.19	37.48	21.63	41.52
SOUTH INDIA Total	68.46	42.35	81.19	48.39	34.18	42.70	45.06	45.12
ALL INDIA	180.57	51.36	188.75	64.34	74.91	57.11	87.24	61.31

[Source: Contemporary Tea Time; 2002; Vol. XI, No 2]

The fluctuation of Volume of Sales and Price for CTC, Orthodox and Darjeeling tea at Guwahati Tea Auction Center and Kolkata Tea Auction Center for the period Jan/June 2001 – Jan/June 2002 are given in Table 1.4

Table 1.4
Fluctuation of Sale and Price For Different Types of Tea at Tea Auction Centers in the Period Jan/June 2001 – Jan/June 2002.

	Type of Tea	Jan/June 2001 – Jan/June 2002.		April/June 2001- April/June 2002	
		%Fluctuation in Sales Volume	% Fluctuation in Price	%Fluctuation in Sales Volume	% Fluctuation in Price
Guwahati Tea Auction Center	CTC	(-) 3.90 %	(-) 26.13 %	(-) 30.81 %	(-) 6.41 %
	Orthodox	(+) 2.82 %	(-) 26.13 %	(-) 16.47 %	(-) 12.34 %
Kolkata Tea Auction Center	Darjeeling Tea	(+) 33.33 %	(-) 22.38 %	(+)26.50 %	(-) 17.54 %
All India	All Type	(-) 4.3 %	(-) 20.17 %	(-) 14.13 %	(-) 6.85 %

[Source: Contemporary Tea Time; 2002; Vol. XI, No 2]

The preceding discussion leads to the following observations:

- Tea was sold at an average price of Rs. 77.49 per Kg at the auction market in 1999.
- Average price dropped down to Rs. 51.00 per Kg in March 2000.
- It has reached its minimum of Rs.45.42 per Kg in March 2002
- Trend of fluctuation is predominantly in the downward direction
- The average fluctuation in sale volume is not proportional to price and shows an upward trend.

From the above observations, following general conclusions can be drawn

- **On an average, price of all types of tea has been falling from 1999 onwards**
- **For all types of tea, sale and price do not vary uniformly.**

1.4.2 The Effects of Fall of Tea Price

Because of the fall in tea price and fall in demand tea planters are worried a lot today. Besides the drastic reduction in their net profit because of low price of tea, it may also lead to growing friction between the tea workers and the management of tea estates in the state.

The low prices of tea in the market for the last few consecutive years have forced many tea companies, particularly the small tea companies, to cut down on expenditures. As a result of cut in expenditures the laborers of the tea estates have not been paid bonus at the usual rate of 20% per year. This has given rise to resentment among the labourers who are feared to ventilate their pent up anger at the drop of a hat. It happened in the Sopai Tea Estate of Assam on May 30, 2003 (The Times of India, 31st May 2003) and may recur at other places in future. ***Labour cost accounts for average 50% of the total cost of production in the tea gardens (Dhanakumar, V.G.; 1996). So it can be inferred that very hard days are ahead for the tea industry unless things get brightened up in the tea market in the near future.***

1.5 Traditional Global Market

The Traditional Global Market of Indian Tea has mainly viewed tea in terms of the differences in:

1). Produce Identity (i.e. appearance features)

2). And/ or in tea processing & manufacturing systems namely CTC and Orthodox.

This traditional system of the tea market classification is good enough to identify different export outlets of 'Tea Disappearance'. But such classification system cannot be helpful in bringing out the changes in the global tea market including aspects such as economic reliability, relation of beverage to life styles and growing sentiments of environment and ecology. Indian Tea unlike Indian Coffee has 'Produce identity' in terms of the geographical conditions: India's 'DARJEELINGS' and 'ASSAMS' have the advantage in establishing their dominance in the globe.

1.5.1 Alternative Tea Market Classification

New market classification is necessary to gain a vital position in the Global Tea Market. It has been tried to classify the markets into two basic categories on the basis of the produce identity and non-produce identity. Such an attempt is made by Indian Institute of Plantation Management, Bangalore. The classification is given in Table 1.5.

Table 1.5
Alternative Tea Market Classification

Produce Identity	Markets	Non – Produce Identity	Markets
Champagne Markets	Saudi Arabia, Germany, Netherlands and Japan	Appearance	Pakistan, Poland, Egypt & Iran
		Bio – Chemical	U.S.A. and Japan
Agro – Chemical Markets	U.S.A. and Europe	Cuppage	East Europe and Russia
Ecology Markets	Europe particularly Germany	Liquid	Iran and Russia
		Impressionable	South Africa, Syria, and Pakistan

1.5.2 New Combination Market for Tea

The global market for tea is now seeking for a new classification which include markets based on appearance, convenience, ecology, cuppage, bio- chemical markets, agro- chemical markets, primary champagne markets, 'less liquid markets (financially constrained) and impressionable markets.

The 'produce identity' markets are the high premium 'specialty tea' segment. 'Specialty tea markets' are no longer just savors of the high aroma, high flavor 'Exquisite Liquor' demanding markets. The countries under different tea markets are given below:

- Germany & Netherlands: 'Specialty Tea markets'.
- U.S.A. : 'Healthy Decaffeinated Tea'
- Japan: 'Green Tea' (encouraged by the nutraceutical properties).
- South Africa, Pakistan and Syria: Impressionable.

As far as the global demand for tea is concerned only liquor and aroma are no longer the quality characteristics for creating its demand. Tea lovers are now searching for non-chemical, healthy, aromatic, refreshing, non-alcoholic, liquoring tea, that too at most competitive price.

It is high time now to go for cost reduction with enhancement in value of tea to gear up to meet the pressures of the global competition.

1.6 Factors Responsible for the Low Productivity in Assam Tea Industry

The productivity in Assam tea industry is considered to be low. The factors for low productivity can be summarized as follows: (Jain. N.K.; 1989)

1. Large area under old tea bushes (45% of area are covered by tea bushes of above 40 years age) with high vacancy, poor bush frame and low plant production per hectare.
2. Slow rate of re-plantation (0.52% in Assam).
3. High water table and lack of suitable surface for quick disposal of excess water.
4. Soil erosion in hilly area.
5. Lack of proper adoption of Agro-Technology.
6. Improper Quality Management Policy
7. Age old production technology

A serious and systematic planning at all stages is necessary to bring about a break through in productivity and cost reduction.

It has been seen that the dismal performance by Indian Tea Industry in general and Assam Tea Industry in particular, is a cumulative long term effect of many factors external and internal to the garden, like

- Traditional structure
- Plantation and replacements
- Uneconomic gardens leading to chronic sickness
- Variable external demand
- High costs of production
- Technological stagnation
- Poor management-employee relationship
- Least emphasis on quality etc.

1.7 Statement of the Problem

In the context of above it can be inferred that Indian Tea Industry is facing a tough time in global competitive scenario. Assam Tea Industry, the largest part of tea sector, is clearly moving on the road of distress in this unstable era of price erosion. The effect of the fall in price of tea has started. Erosion in profit level is leading to irregularity in wage payment, which finally results in frequent conflict between workers and management. A sizeable number of gardens under government control are under the process of closure. Some company-owned and proprietarily-owned gardens are in the stage of incipient sickness with fall in profit level. This incipient sickness of these gardens will gradually turn towards chronic sickness if some drastic steps are not adopted now. It has been felt that the only way to bail out of this situation is to focus on improvement of quality of tea. Every garden must now plan for improving quality of their tea.

Assam Tea Industry, being a British originated sector is partially traditionally closed type of organization. Assam tea till the mid of 1990's was second to none in terms of quality. This quality aspect in Assam tea was the result of many factors like the climatic factors, environmental factors, geographic factor, cultural factors, unknowingly traditionally adopted factors etc. Quality was the ultimate result of interaction of these factors.

The conceptualization of the factors that drive a tea garden to perceive "quality" is depicted in Figure 1.4

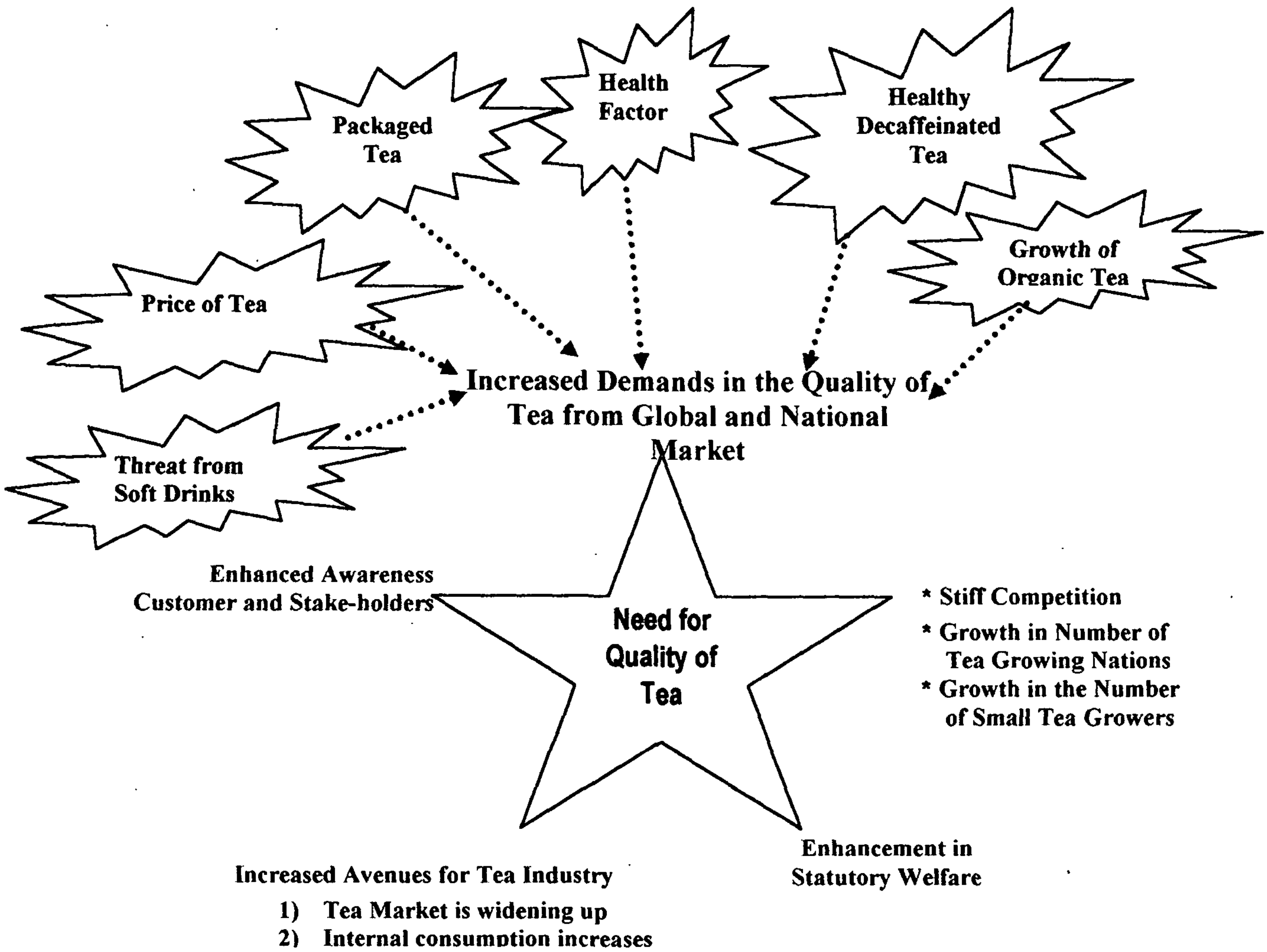


Figure 1.4
Need for Quality in Tea Industry

As it can be seen that factors like threat from soft drinks, demand for decaffeinated tea, development of organic tea, rise in the demand of packaged tea, customer's inclination towards healthy tea etc. have compelled the tea industry to put impetus on quality of tea produced. These factors accompanied by enhanced customer awareness, enhanced govt. statutory welfare, rise in number of tea growing nations, growth in number of small tea growers etc. have put momentum to the need of production of quality tea.

Quality of output for any sector is the result of its components within the system. Quality product is the result of quality minds, quality technology and quality environment. Quality of tea cannot be achieved only by using better production machineries or by adopting attractive packaging. Quality aspect must be taken care of at all spheres of tea production starting from planting of tea plants to dispatch of made tea. In this era of crisis in Tea Industry, the only answer to stabilize growth and maintain it, is "Relentless Improvement in Tea Quality" along with "Never ending reduction in unnecessary cost". In other words: - "continuous Improvement in every sub-system of Tea Industry with a view to enhance ***Value of Tea***" is the 'mantra' for survival.

In view of the above issues the present work has been undertaken with special reference to the Tea industry in Assam. The Tea industry in Assam has been given special consideration due to its impact on regional and national economy and homogeneity in regards to culture, topography and other environmental factors.

1.8 Objective of the Study

The objectives of the present study are

- to identify the factors contributing to quality of made tea at the garden level
- to identify the management controllable factors
- to assess the feasibility of Total Quality Management (TQM) initiation in Tea industry
- to develop a measure for assessment of standing of a tea garden in terms of total quality culture
- to develop a Systems Dynamics causal model for quality management aspects in a tea garden

1.9 Scope and Limitations of the Study

This thesis presents an analysis of factors affecting Quality of tea and classifies them into garden controllable and garden un-controllable factors. It also describes some of the key areas of production where continuous improvement is needed for sustained growth of tea industry of Assam by implementing the concept of **TQM**. The analysis is supported by group and individual opinion pre-collected through Interview and Questionnaire survey.

In the process of finding out the factors affecting Quality of Tea, the Tea Manufacturing System is segregated into different sub-systems and the causality of the factors are studied. While finding the factors at sub-system level, the key areas where cost reduction is viable are also studied here. An attempt has also been made to ascertain the present prevailing level of quality consciousness in this industry. An attempt has been made to develop an appraisal tool to ascertain the degree of improvement achieved and compare the levels of Quality activities by different gardens.

The study is based on data and information collected from a few tea gardens in Assam. The study has been confined to the activities of the tea garden only. The data and information have been collected from persons working inside the garden. Views and policies of the Company owning the gardens at strategic planning level have not been considered.

The models developed in the thesis are generic in nature and can be applied to any tea garden with minor modification. The 'Tea Information System' provides a holistic picture of processing activities as well as the culture of the work force in the tea garden.

The following are the limitations of the present study:

- The present work on TQM application in Tea Industry is limited to the Tea industry in Assam only for its homogeneity in regards to culture, topography and other environmental factors.
- The study aims at finding the basis of TQM implementation and its applicability in tea gardens of Assam and does not focus on procedural implementation of it.
- While assessing the wastage in tea manufacturing, study has been limited to the energy sector only

- The researcher had to rely on whatever information was provided by the respondents for developing the model for the assessment tool, TQMI. The validity of the model is dependent on the reliability of their responses.

1.10 Organization of the Thesis

The text of the thesis has been arranged in eleven chapters as follows:

Chapter 1: In this chapter, the importance of Assam Tea Industry in Indian scenario has been emphasized. The recent trend of this sector along with the challenges of this agro-based industry is highlighted leading to statement of the problem and objectives of the research work undertaken.

Chapter 2: The review of literature has been reported in this chapter under two heads, the first one on Total Quality Management (TQM) and the other on Indian Tea Industry. The main thrust of "An Overview of Total Quality Management" is on the strength of TQM philosophy and its success/failure stories in different industrial sectors. The other section "Studies on Tea Industry", deals with the reports on various improvement activities undertaken in Tea sector.

Chapter 3: The knowledge of manufacturing process of tea is of great significance as it deals with the basic building blocks of tea quality. In general, TQM point of view demands a generalized understanding of the product which includes the basic manufacturing process. Chapter 3 of the thesis discusses the processes involved in tea production.

Chapter 4: This chapter deals with the identification of factors affecting the quality of made tea. Attempt has been made to construct a model using Ishikawa Cause and Effect Diagram and SD Cause and Effect diagram to depict the causality of each of the factors affecting Quality of Tea.

Chapter 5: This chapter deals with an analysis of pattern of energy consumption in tea processing and estimation of wastage in this sector.

Chapter 6: The chief internal stakeholders in a tea garden are its employees. This chapter of the thesis presents, how the feedback from the stakeholders, could be used for gap analysis and determine the existing environment and arrive at the drivers and the inhibitors that facilitate/restrict the introduction of TQM in the system.

Chapter 7: The performance of a tea garden, as per TQM terminology, is based on development of all the sectors of a tea garden simultaneously. In this chapter of this thesis an attempt has been made to introduce a new concept of TQM Indicator using totality concept. This chapter also deals with the mathematical modeling for TQM Indicator for each of the sectors (sub-system) of tea garden. The development of TQMI and PI has been dealt in this chapter in a detailed manner.

Chapter 8: This Chapter deals with the applicability of the TQMI model developed for various inputs from sample tea gardens.

Chapter 9: An attempt has been made in this Chapter to develop a Tea Information System (TIS) dealing with various aspects of Tea Industries and Computation of Total Quality Management Indicator for a Garden.

Chapter 10: This Chapter presents the causal mechanism prevailing among the factors affecting the TQMI of a tea garden. The various loops of the system have been identified and analyzed.

Chapter 11: This concluding Chapter presents the summary and conclusions of the research work. The Scope for future work is also discussed.

The thesis ends with references and a set of appendices.

Chapter II

Review of Studies on Total Quality Management and Indian Tea Industry

2.1 An Overview of Total Quality Management

Total Quality Management has been adapted by some companies in India, though the number of such companies is small compared to the number of companies that have obtained ISO9000 certification. This section discusses an overview of Total Quality Management, the status of TQM in industries and the reasons for its debacle, based on literature scanning.

2.1.1 Introduction

As conceived by Aristotle, achieving a good and happy life is Ethics. Management ethics is concerned with creating good organizations to achieve excellent quality in the production of goods and services. Thus, Ethics and Quality are integral part of management. Peter Drucker (1977) pointed out that ethics and quality are the core areas in management of an enterprise. He believed that ethical and socially responsible management provides continuity for the organization. One important dimension of socially responsible management is responsibility or accountability for the social consequences of products and processes. "One is responsible for one's impacts, whether they are intended or not" (Drucker, 1977). This involves taking action to address problems, even before society might force business to regulate or change behaviour. This is in contrast to the more limited view (Friedman, 1970) that business only has a responsibility to comply with legal requirements and basic norms, i.e. a more community-based and long-term perspective needs to be accounted.

Ethics (doing right things) and quality (doing things right) represent complementary dimensions - the soft and hard sides - of management. Further, both are a philosophy as well as a process, each seeking to optimize organizational behaviour by clarifying the purpose and nature of work.

The Scope of business has been extending dramatically from a mere "an organization for profit" to "serving the society and its implications in the longer run". This concept is represented in Figure 2.1. Thus an organization has a multi-dimensional focus such as, coping with market dynamics, stakeholder focus, customer focus, government regulations and social/ethical issues. Hence the holistic approach to the organization is the need of the hour. In the process of catering to the changes of the society, organization too needs to change the strategies.

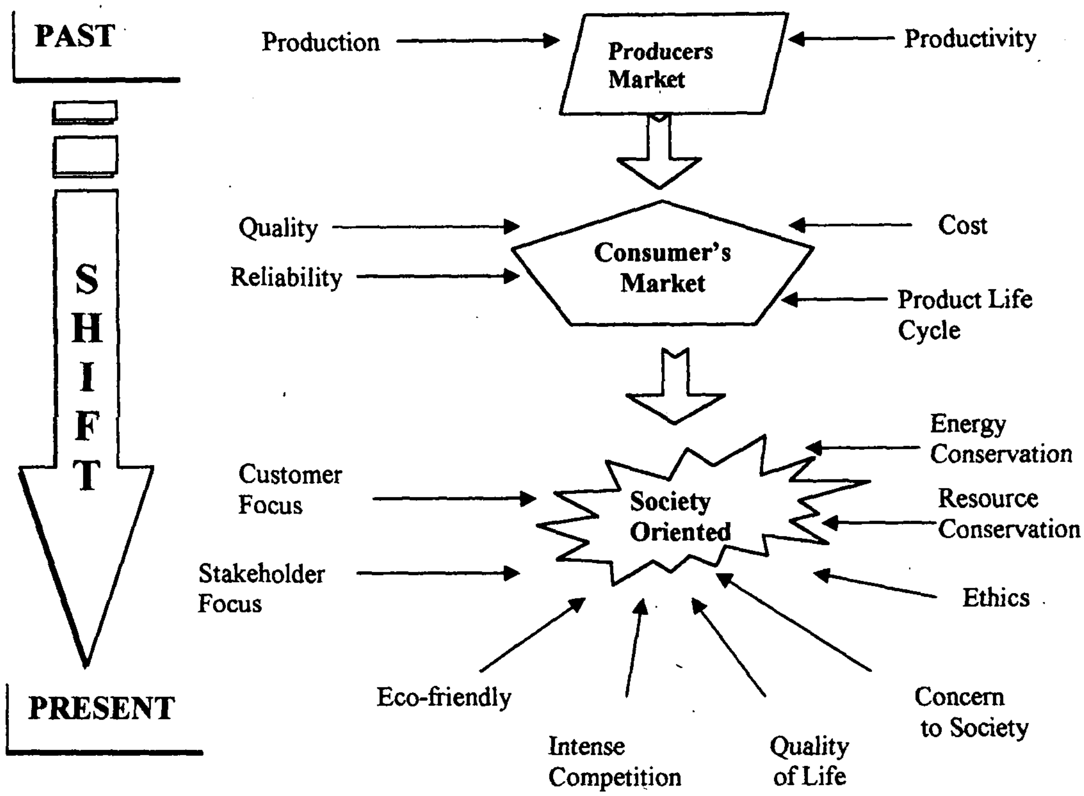


Figure 2.1
Shift in Focus of an Organization (Bhushi. U.M., 2002)

The organization caters to these varying requirements of customer demand meeting the social obligations. The stakes for society is quite large enough to encompass the various dimensions. To answer the question of how to encompass these dimensions, many paradigms have come and gone. But the one that accounts all these dimensions is answered by "TOTAL QUALITY MANAGEMENT" (TQM). And TQM has rapidly become the business philosophy of the day. TQM has been acclaimed as process-oriented organizational philosophy to improve business activity, which enhances the global competitiveness and customer satisfaction through the production of high quality goods and services.

2.1.2 The Development of Quality Management

2.1.2.1 A Brief History of Industrial Total Quality Management

Development of TQM in the industrial setting has spanned virtually throughout the twentieth century. TQM had its rudimentary beginnings in the work of Frederick Taylor and his theories on scientific management. Simultaneously, Japanese managers at Toyota Motors, Dr. Walter Shewhart's work at Bell Laboratories, Deming's PDCA cycle, Juran's Total quality control, Dr. Armand Feigenbaum use of the concept of "cost of quality" and Crosby's "zero defects" program and many similar works have carried the "QUALITY" down the decade with varying definitions, meanings and understanding. TQM has been used as a strategic weapon by majority of the industries worldwide to meet the dynamic environment and changing needs of the customers, leading to both success to some extent and failure to a greater extent. Thus looking at TQM as a "FAD", the theoretical foundations for TQM came from several people, including Deming, Juran, Crosby, Taguchi, Ishikawa. TQM has evolved to mean many different things. Collin's "Dictionary of Sociology" describes Total Quality Management as: "Managerial technique in pursuit of continuous improvement through strategic, procedural and cultural change in organizations" (David and Julia 1995).

Nonaka and Takeuchi (1995) emphasized TQM as a management system theory that is a blend of American scientific approach with Japanese holistic traditions of the oneness of humanity and nature. Oneness of body and mind and the value of interaction between self and others are instrumental in the economic success of Japanese after the World War-II.

Deming, Juran and Ishikawa agree on the importance of scientific methods (a constantly evolving theory interacting with empirical data), for controlling processes and quality. They strongly emphasized the importance of statistical method to monitor process performance and identify areas of improvement (Deming 1986).

W. Edwards Deming, credited with the Japanese 'Quality Revolution' of the post war era, quoted "We have learned to live in a world of mistakes and defective products as if they were necessary to life. It is time to adopt a new philosophy in America". And "Our aim in production should be to improve the process to the point where its distribution is so narrow, the specifications are lost beyond the horizon." That is, we should learn enough about our processes to be able to set process target nominal such that the variation around those nominal is minimal. (Deming website)

2.1.2.2 Perception of TQM: Theory and Practice

TQM's view of processes is seen as an interaction of five generic types of resources: people, method, material, equipment and environment. This resembles the ideas of socio-technical theory developed at the Tavistock Institute. (Deming 1986, Burrell and Morgan 1979). Figure 2.2 shows the parameters of TQM.

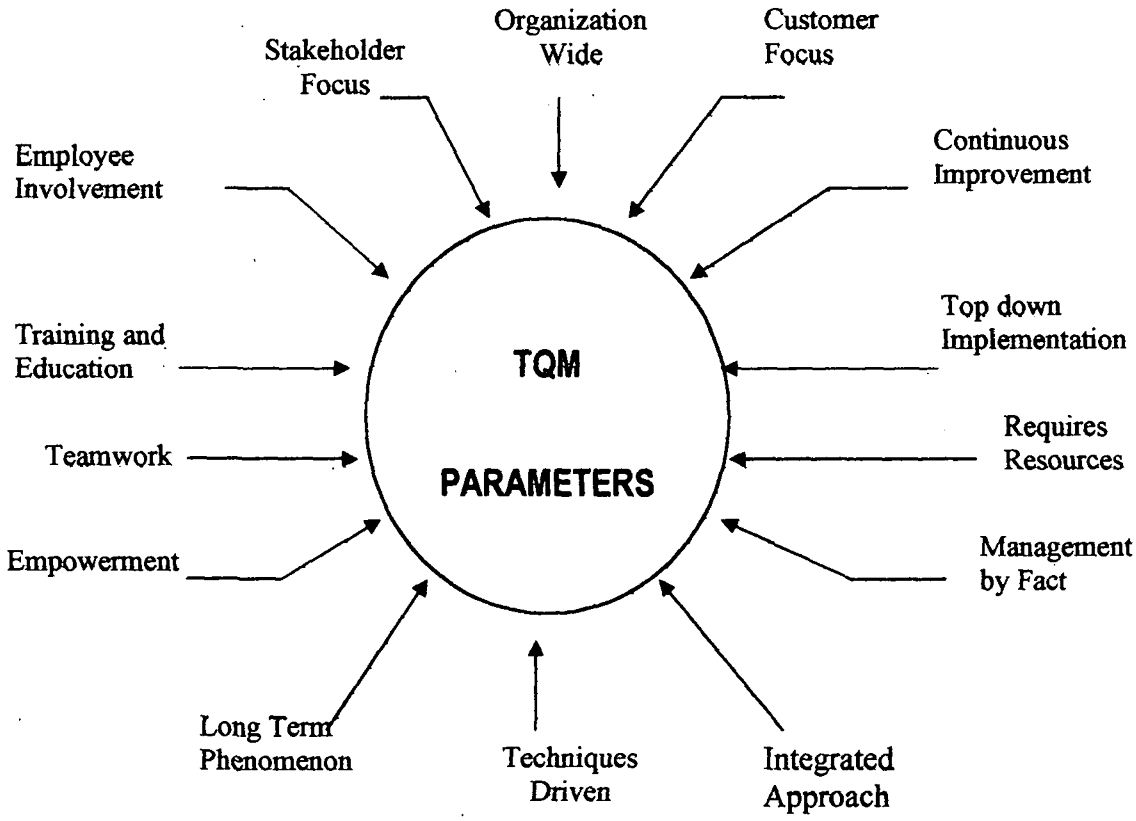


Figure 2.2: Perceptions of TQM Philosophy

The approach of TQM concept is systemic in nature. It encompasses both the Socio-technical and Contingent theories, integrating every facet of organization (Business/Service). Such an overall system improvement leads to high quality product and cost reduction, that gives an organization/firm a competitive advantage in improving the total efficiency, effectiveness and its adaptability.

2.1.3 Status of TQM in Industries

Although ISO 9000 certification became the symbol of quality-oriented company, a mere certification does not guarantee quality. Adopting TQM would ensure a company to achieve the desired quality. Many companies went beyond ISO 9000 towards TQM, hence there was a wide spread acceptance of TQM in several countries. TQM was embraced in the developed countries first. India made a late entry into both ISO 9000 and TQM.

2.1.3.1 Incidences of Successful Implementation of TQM

- Robinson, et al. (1991) pointed out that American Express, Ford, IBM, Motorola, Procter & Gamble, and Xerox have halved the product development cycle, 75 per cent improvement in "things gone wrong" in shipped products, and to a US $1.5 billion savings in scrap and rework over a five-year period.
- Over the nine-year history of the Baldrige award (Malcolm Baldrige National Quality Award is a US federally administered award program which tries to identify companies who are practicing TQM), winners have outperformed the S&P 500 by almost 3:1. Even companies who did not win the award, but who received site visits from Baldrige examiners, outperformed the S&P 500 by more than 2:1. (skymarkwebsite)
- Evans (1995) listed the following TQM successes:
  - Nestlé Chocolate and Confections, a division of Nestlé Food Company, reported in the mid of 1990's that their total quality efforts saved £4.1 million in the first year, £11 million in the second and £20 million in the third. Return on investment grew from 15 per cent to 22 percent.
  - ABB Zamech of Poland, heavy power generation equipment makers, recorded annual turnover rise from $80 million to $150 million in about three years after the introduction of TQM in 1990.
  - San Diego-based biotechnology firm, Hybritech's turnover had grown from $50 million to $145 million, and a $20 million loss transformed into a $36 million profit, in a span of four years after the introduction of TQM.

2.1.3.2 Incidences of Failures of TQM Implementation

However, it is reported that many companies could not adopt TQM successfully and therefore, could not gain the benefits out of it. Reports of the failure of TQM implementation are presented below.

- KPMG (1989) productivity survey conducted among electronics manufacturers in USA indicates that over 90 per cent of the respondents claim TQM as a competitive tool, but only 15-20 per cent say that they have implemented TQM.
- Wright (1993) reported that TQM success rate in USA is 25% and that in UK is only 20%.
- Eskildson (1994) found that the American Electronic Association's quality programmes dropped from 86% in 1988 to 73% in 1991. Of these, around 63% failed to reduce internal defects even by around 10% in spite of TQM programs being in use for 2-3 years. He also found that in Britain, only 20% believed that their quality programmes had a significant impact on their organization.
- Fisher (1994) and Brown (1993) also reported about 80% failures in implementation of TQM in American Companies
- Paton (1994) stated that a study of 30 quality programs by McKinsey & Company found that two-third of the quality programs failed to yield real improvements. A study by Rath et al. reported that only 20% of Fortune 500 companies were satisfied with the results of their TQM activities.
- Gatchalian (1997) generalized, from his surveys, that the proportion of successes in TQM implementation was only within the range of 20 to 35 per cent of those who have initiated the practice.
- Singh (1991), in his survey, revealed that only 39 companies out of 1000 surveyed are practicing TQM to some extent in India. Moreover, he concluded that these 39 organizations were also not able to distinguish between TQM and quality control.

If one could see completely across the global corporate horizon, there are possibly many TQM implementation disaster stories than that of TQM successes. Failing to capture the full potential of TQM and improper implementation have led some managers to dub TQM as a fad.

2.1.4 Reasons for Failure of TQM

Some of the reasons of failure of TQM as attributed by various quality professionals are:

- ❖ **Culture Change**: Develin and Partners (1989), Dale, et al. (1997), have stated that the key factor to obtain a successful implementation of TQM is change of organizational culture and emphasized that a structured approach is required. However, they feel that the approach to change organizational culture remains largely unclear in most cases, and therefore full potential of TQM is not achieved.
- ❖ **Quality Policy Communication:** Crosby (1979) emphasized quality policy as a standard practice, which sets priorities by influencing the entire organization on what to do and what not to do and provides the launching platform for the implementation of TQM. Failure to communicate this quality policy actually defeats the purpose of having the policy in the first place followed by a failure of TQM.
- ❖ **Top Management Commitment:** Bertram (1991), Juran (1993), and Easton (1993) have all attributed the lack of "Top Management commitment" for the failure of TQM or quality initiatives.
- ❖ **Leadership:** Zairi (1994) pointed out that the lack of enough know-how and capability of the leadership to properly implement the quality programmes, inhibits the momentum of TQM implementation.
- ❖ **Delegation and Involvement:** Corrigan (1995) recognized that the debacle of TQM quite often comes forth because of too much delegation of TQM responsibility without personal involvement of the Top Management in TQM efforts.
- ❖ **Poor Strategic Vision:** Gatchalin (1997) indicated the following for failure of TQM:
- The absence of strategic communication and teamwork for quality improvement from the Top Management.
- High emphasis on short-term strategic goals that are financial in nature, i.e., expectation of immediate monetary benefits

The common reasons for failure of TQM implementation are represented in Figure 2.3

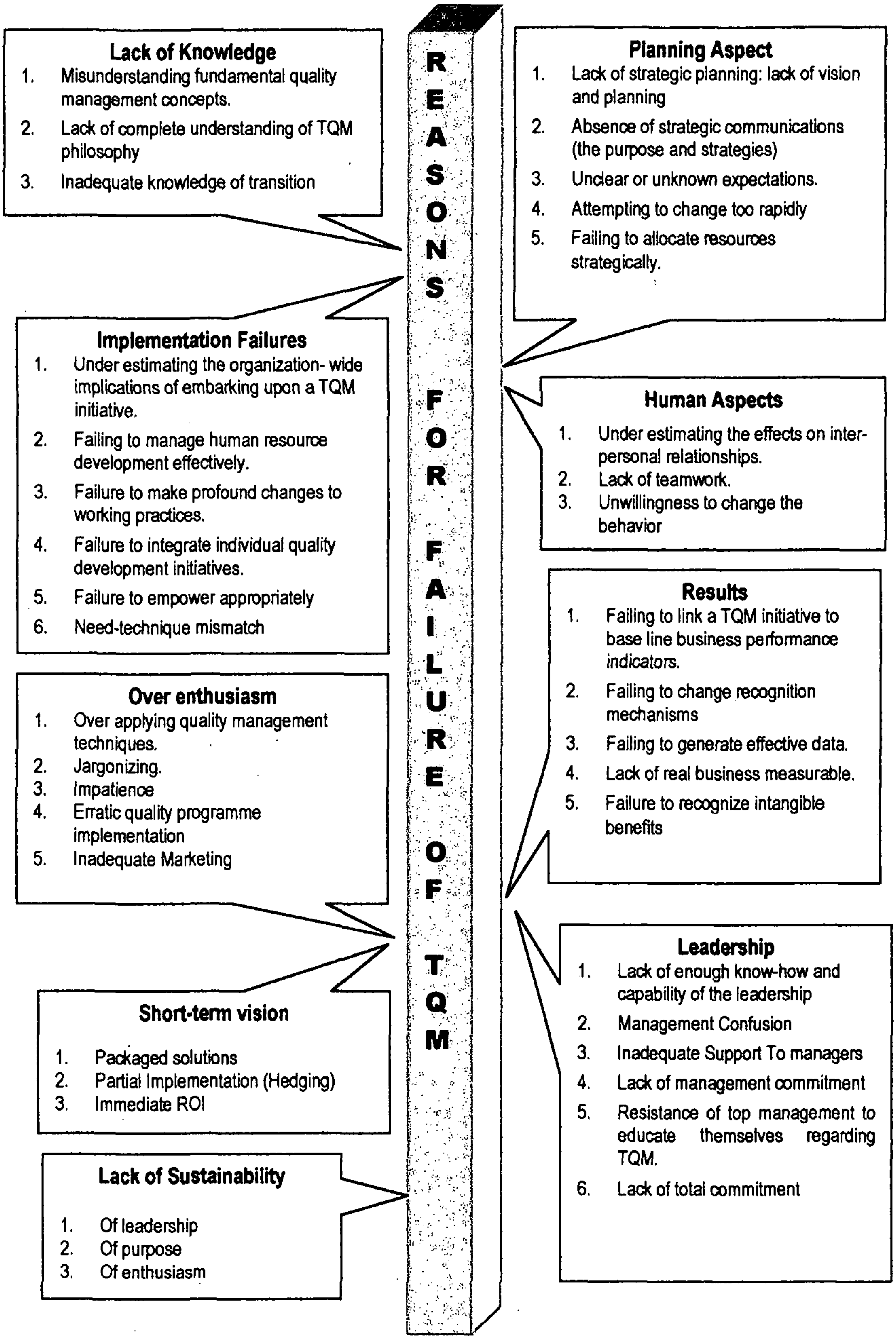


Figure 2.3: Common Reasons for Failure of TQM Implementation

To summarize, the Company's existing culture, lack of top management commitment, non-communication of quality policy, diluted responsibilities, absence of strategic communication, lack of team work, higher emphasis on short term monetary goals, lack of knowledge and leadership capability are the reasons found by several authors for failure of TQM implementation.

The approach to TQM implementation, therefore, needs to be developed deeper in order to come out with a more rational understanding of the concept and to formulate a strategy to work towards a more effective implementation of TQM (operational reality), to truly fit their company's requirements and foster the success of TQM journey.

2.1.5 Summary of TQM Practices

TQM has been partially successful as a paradigm for most organizations in gaining the competitive advantage or in enhancing the overall quality of the organization, due to lack of a holistic approach during its implementation or due to improper strategic thinking. Again the impatience, improper platform akin to that in ISO certification played part in damaging the basic purpose of TQM.

TQM will be successful if some of the cautions mentioned below are adhered to:

- The drive for improvement for an organization should not be a problem driven improvement process. First, assess the preconditions and the current state of the organization to make sure that there is a need for change and that TQM is an appropriate strategy.
- The Approach should be humanistic. TQM does not fail or succeed because of techniques. TQM fails or succeeds because of people. If TQM is to become an operational reality within organization then it is a fundamental requirement that human dimension be meticulously taken care of in terms of gaining their trust, imparting training, keeping/maintaining their enthusiasm, long term security and interest.
- Improvement of the process is on a continual basis.
- Account all the intangible benefits accrued in the initial phases to the people at all levels so that the faith in the quality management is not lost.
- Develop an in-house strategy for implementation of TQM; though initial stages can take assistance of the agents, and gradually develop its own internal team to manage the same, i.e. it should not be sold to consultants solely.

- The gestation period should be assessed so that programs are not shelved down/negated before the period.

Drucker(1989) has aptly commented that TQM is a good idea. Like many good Management ideas, it has the unfortunate tendency to degenerate, into hard work. TQM is hard work, it is not hard physical work, but it is hard emotional and mental work. The successful implementation of TQM is hard work because it requires many people and managers in particular, to change beliefs and attitudes that have proved relatively successful in the past, to think more effectively and most importantly to change what they do in the contexts of their working lives. TQM should become a way of life and a long-term perpetual improvement process.

The challenge of TQM is, first and last a human challenge. It is not simply about techniques, systems and procedures, but primarily about values and attitudes and ultimately business ethics.

2.2 A Resume of Reported Studies on Indian Tea Industry

Tea industry receives wide coverage in the daily newspapers and the economic weeklies of India. The large number of studies reported on various aspects of tea industry truly reflects the role of this industry in the national economy. These reports comprise views of the planters, researchers, social scientists, economists, and experts in committees formed by the government and the planter's associations. They mainly touch upon agro-botanical, marketing, manufacturing, and economic aspects of the industry. The first two aspects, however, have received higher priorities primarily through the activities of the research organization at Tocklai, Jorhat and through the concern expressed by the government and planters from time to time, as evidenced by large number of seminars and committees etc., respectively.

No attempt is made here to discuss the reports of the agro-botanical studies on tea plants. Other important studies directly related to the present investigation are highlighted below to form a backdrop against which the results of the present investigation could be debated.

Most of the studies reported during 1950-1980 indicate a close similarity among recommendations made. Almost all of them visualize a very rosy picture so far as the demand for tea around the turn of the century was concerned. Hence, the concern was invariably in planning for long term production and selling tea profitably. Various suggested schemes for planning for long term production include extension planting, replanting, modernization of factories, building up a trained labour and managerial force and augmenting R&D activities and implementing its results etc. No serious suggestions regarding ways for increasing profitability have been put forward by any study except reaffirming faith on the distribution system through auction, emphasizing on intensive market research, particularly in foreign markets. Most of the reports on Tea industry till date are quantitative in their approach and recommendations. However, certain studies significant for their innovative views are discussed below.

Roy (1980) is of the view that a limited cobweb type phenomenon is responsible for a long term price fluctuation of tea, and that the short-term price instability is largely due to real or assumed over/under production. Analyzing the adverse impact of the International Tea Agreements of 1933 through 1955 on the growth of tea industry, Roy suggests that India should refrain from signing such agreements in the future. He also suggested that the tea trade be fully taken over by the government with controlled flow to auction after fulfilling the demand for the foreign market with a view to creating an excess of demand over supply to stabilize price.

Jain(1989) has indicated various potential areas towards which the Research and Development activities should be oriented for long term improvement in productivity and reduction in cost of production.

Sahu (1979) has indicated various potential areas of the industry such as general management, management of production in field and factory, capital investment, cost reduction, financial management, marketing management, etc., wherein the popular techniques of Industrial Engineering could be fully employed.

On the basis of an analysis of strength, weaknesses, opportunity and threat to the industry, Garodia (1979) argues that doubling of tea production is possible with the existing production area itself if research activities can be furthered and are result oriented. Emphasis has been given on proper bush density, replanting, and on rearing the tea bushes with utmost care in order to obtain the best results. Garodia has put forward a new idea of visualizing the future requirement in terms of number of cups of liquid tea rather than in terms of dry leaf, as the different types of dry leaf manufactured by different processes (CTC, Orthodox etc) produce different number of cups of liquid tea per unit of dry leaf.

Baruah. P.C. (1984) discussed some of the productivity techniques like manpower planning, job evaluation, work study, material management, maintenance management, production planning and control, operations research techniques etc. Baruah points out the possibility of applying those techniques in tea industry.

Bhagat. K.R., (1998) points out that the output at the end of a day in a tea garden has got direct bearing to the quality of work performed in various sectors by the garden workers engaged in various stages of field and operations. He has shown that the yield from land, and labour productivity, have been showing a downward trend (Fig. 2.4 and Fig. 2.5). Bhagat has suggested some measures related to labour and plantation operations for improved productivity of a garden.

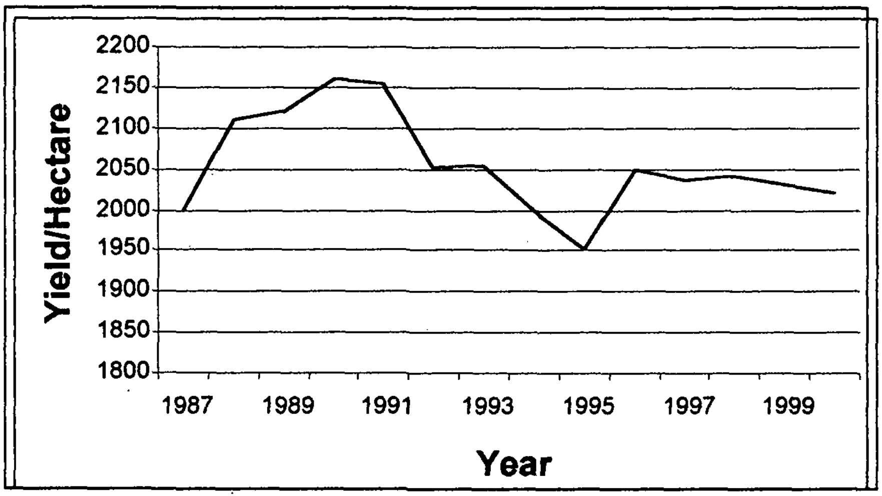


Fig 2.4
Yield per Hectare of Assam Tea Gardens

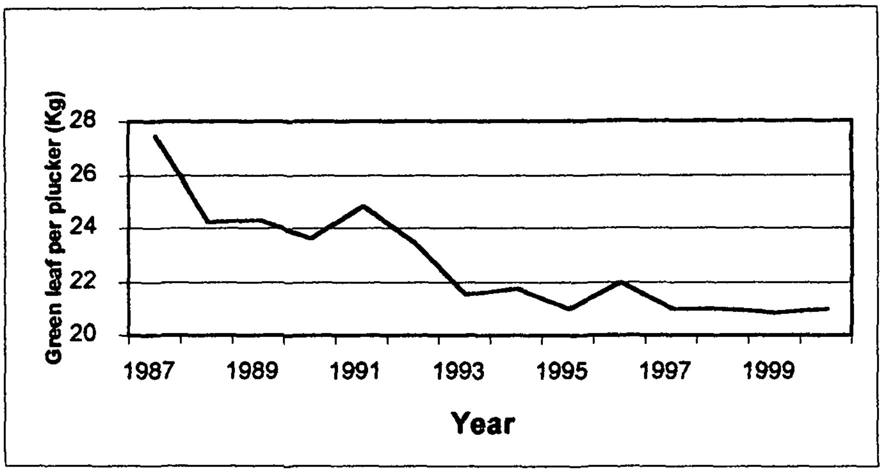


Fig 2.5
Green Leaf Plucked Per Plucker in Assam Tea Gardens

Sarronwala (1995) tried to put up a convenient organization and management structure of a tea garden for better output in terms of productivity. He also discussed the objectives, duties and responsibilities of persons under each designation of the management structure.

To improve tea quality, Dhan (1995), suggested for putting more importance on management front rather than putting isolated effort to bring out the cup characteristics of tea. He advocated the implementation of TQM in estate management covering all aspects of agriculture, manufacture and administration including human resources development.

Baruah. T.C., (1984) illustrates briefly the work done in Tocklai Experimental Station mainly on development of newer tea machineries which are of continuous type, more efficient, compact, cheaper and easy to install and operate.

Gupta (1999) critically analyzes the weaknesses of conventional CTC machines and the necessity of further research in this direction. He proposed to apply the 'concept of product development' for development of improved tea machineries as followed by other industries. He stressed on development of machines for higher accuracy and productivity enabling them to produce leaf style (Grade mix, density and bloom) and liquors (thick, bright with cuppgae).

Khanna (1999) describes the importance of withering process of tea manufacture stressing on physical and chemical aspects. He probes into the different existing withering methods and their relative advantages and disadvantages. Khanna stressed on the need for improvement of the trough system for meeting the challenge for future.

Arora (1995) discusses the new concepts of tea drying and presents a comparative analysis of VFBD (Vibratory Fluidized Bed Dryer), microwave heating, heat pump, flash cum fluidized bed drying.

Das (1997) points out the fact that major savings can be achieved by switching over from oil to coal firing. He also suggests that the performance of coal fired tea dryer can be improved by switching from manual firing to use of mechanical strokers.

Sooriamothi, et al., (1993) classifies the energy consumption in tea manufacturing into three groups, viz. thermal, electrical and human. The deviation from the standard is used as an indicator to reflect the waste in the production process.

Desilva (1994), critically analyses the energy requirements of various drying processes. The various points of wastes in tea drying process have been mentioned. It has been commented here that if there is any scope of further reduction in consumption of energy, it lies in cutting down the exhaust air losses. But there is a constraint in reducing these losses below a particular value as the made tea has to be discharged at a moisture content not exceeding 3%.

It can be noted here that ECP (Endless Chain Pulley) traditional dryers are in use in many tea gardens of Assam for many decades. The highest efficiency that can be obtained in such dryer in relation to operating parameters is about 36% which is very low (Das 1997).

Dhanakumar (1996) deals with how human-quality relations will emerge in the future. Here, he identifies 'people' as the most underutilized resource of tea industry. A case study is presented on how the United Planter's Association of Southern India-*Krishi Vigyan Kendra* implemented TQM approach within the framework of 'totality' in active participation of every employee from the top to the lowest echelon. It has been revealed in this study that the biggest influence on cost and quality of tea industry is the cycle time starting from the arrival of raw material to the delivery of the made tea. It has been concluded in this paper that:-

- TQM will lead to change in tea industry culture
- Totality cannot be improved by high investment in technology alone

- ❖ Totality comes from people
- ❖ Totality is a result of attitudes and values
- ❖ Industrial climate and culture decides the quality products and services

Bora (1981) carried a detailed Delphi Study to drive into the weak areas of tea industry responsible for price fluctuation of tea. The whole tea industry is divided into four major sectors, viz., production, domestic marketing, export, R&D. Each sector is divided into ten sub sectors. Using Systems Dynamics, a composite model has been developed and various policies leading to long term price stabilization of tea is carried out after validating the model. The additional feature of this work was that of development of a simulation package: DYMOSIM.

"The Quality Factor" (2002), describes the implementation of several strategies to support and prepare the predominant tea sector in Nilgiris to tackle the development arising out of the globalization in the market.

Bhattacharjee, (2002) carried a survey on the financial health of a public sector tea industry. The causes for the ill health of the unit under study have been systematically made. The remedial financial measures for upliftment of the unit have been suggested.

"A saga of success" (www.teatalk.com) describes the success history of a Kenyan Tea Company. The basic reasons for their success are attributed to:

- ❖ hard work, dedication
- ❖ deep rooted culture and core values
- ❖ company's policy of considering its people as their greatest asset
- ❖ sound principles and practices
- ❖ management's policy of "never compromise on quality"
- ❖ management's effort for continuous improvement
- ❖ employee's participation as teams in improvement of processes
- ❖ management's effort to enhance personnel, & ethical values

Some of the key features of the management philosophy of this company are:

- Accessibility-Open Door Policy
- On-going Training & Development
- Discipline & Respect at Every Level
- Participative Management Style

- Performance Appraisal System
- Excellent Employee Compensation

These reported studies have highlighted the problems afflicting the tea industry. In the context of Assam Tea, no known literature is available on application of TQM. Cultural and geographical differences make the study of implementing TQM in Assam Tea industry different from tea industry in South India. This strengthens the need for feasibility study of implementing TQM in Tea industries of Assam. Initiation and effective implementation of TQM in Tea Industry of Assam requires an analysis of the Industry to formulate a strategy, specific to the industry, to highlight the requirements and foster the journey of TQM. A valid mathematical model, with which one can explain the present industry behaviour and recommend structural and policy changes, is expected to benefit the whole industry.

Chapter III

Tea Manufacturing Process

3.1 Tea Production System

The study of manufacturing process of tea is of great significance as it deals with the basic building blocks of tea. In general, TQM point of view demands a generalized understanding of the product which includes the basic manufacturing process. Thus this part of the thesis discusses the processes involved in tea production.

The production system for made tea is similar to that of any other industry. That is, 'Tea Manufacturing System' comprises of an input, an output and a process. Fig 3.1 shows the tea production system.

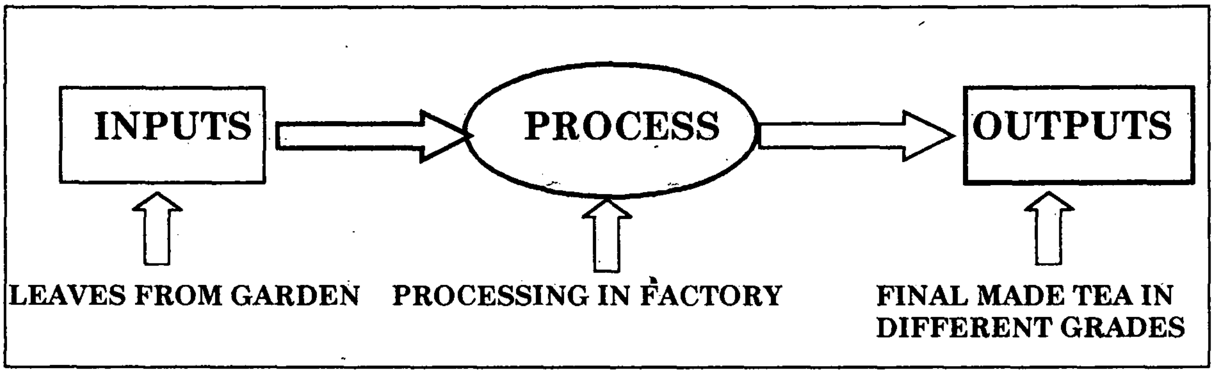


Fig 3.1
Production System of a Tea Industry

The **inputs** are in the form of green tea leaves plucked from the garden. These leaves are carried to the factory for further processing. **Process** is the tea manufacturing process which takes place inside the factory. The plucked tea leaves, which is the raw material in the factory, undergo various processes. The **output** is the final made tea.

3.2 Classification of Tea

Based on different types of processing techniques, tea can be classified into four broad types (Baneerjee. B; 1993):

- Green Tea or Unfermented Tea
- Oolong Tea or Semi fermented Tea
- Instant Tea
- Black Tea or Fermented Tea

3.2.1 Green Tea

A brew made from green tea is similar to the one prepared from dried tea leaves in taste and composition. In the manufacture of Green tea, three principal operations are involved – pan firing or steaming, rolling and drying. The objective is to destroy the enzymes in the tea leaf as soon as it is plucked, thus preventing fermentation all together.

3.2.2 Oolong Tea

It is an intermediate type of made tea between green and black tea. While the latching process is the same as that of green, Oolongs are allowed to ferment while green are not. On the other hand, the fermentation is only partial and not optimum as in black tea. The oolong tea has the colours and appearances of black tea but it has flavour and taste of green tea.

The green leaf in case of Oolong manufacture, is slightly withered before panning, thereby allowing a light fermentation to develop.

3.2.3 Instant Tea

It is a ready-to-drink beverage just like instant coffee. The basic objective in the manufacture of instant tea is to extract the water soluble solids from a pure tea brew, and convert them into a powdery form. The brew can be prepared from black tea, or from partly processed green leaves. This method has been patented by Tocklai Tea Experimental Station, Jorhat (Assam).

3.2.4 Black Tea

The basic objective of black tea making is to condition green leaf for fermentation, and when that has been achieved, arrest the fermenting process through application of heat. Thus heat is to be applied at a much later stage than that of green tea manufacture. The basic operations involved in black tea manufacturing are: Withering, Rolling (plus crushing, tearing and curling in case of C.T.C.), Fermenting, Firing, Sorting and Grading, Storage and Packing.

Due to heavy demand of black tea, most of the tea estates are concentrating their production on black tea only. Black tea can be further subdivided into:

1. Orthodox Tea
2. CTC Tea

All the big tea estates of Assam have facilities for production of both the Orthodox and CTC tea. But now a days, as the demand for Orthodox tea is poor whereas its production cost comparatively higher, hence tea estates focus on CTC tea manufacturing.

3.3 Processes Prior to Manufacturing

Tea leaves are first plucked from the gardens which are normally spread over hundreds of acres of land and then transported to the factory. In the factory, it goes through various stages of processing to get made tea.

3.3.1 Plucking

Plucking is the process of collecting tea leaves from the bushes. The plucked leaves are transported to the factory for processing. Two standards of plucking are normally followed in tea gardens: fine and coarse plucking. Plucking fresh leaves with two leaves and a bud is termed as fine plucking. This type of plucking results in best quality of tea after processing. So, in most of the tea gardens, fine plucking is adopted when quality tea is to be produced. But when demand for tea in market increases, gardens can not meet the demand by adopting fine plucking only. In such a case, plucking is carried out irrespective of freshness and age of leaf. This type of plucking is termed as coarse plucking.

Photograph 1
Plucking of Tea Leaves

In the tea gardens of Assam Pluckers pluck the tea leaves and put it on a basket made of bamboo. The pluckers carry the baskets on their shoulders. The plucked leaves, when the basket is full, are kept on leaf carriers. The leaves are then carried to the factory for processing.

3.3.2 Pruning

Quantity and quality of crop in a tea estate depend largely on pruning practices. Pruning is the process of removal of the top congestion of the bushes by the removal of dead, diseased and unproductive branches at certain interval. This interval is known as pruning interval. Pruning also arrests unproductive growth and stimulates vegetative growth. . In tea gardens of Assam, three to four year interval is followed.

Thus, the main objectives of pruning are (Chakravatee et al., 1994):

1. To check reproductive growth and provide stimulus for vegetative growth, especially for the production of young shoots that constitute the crop.
2. To remove the dead or unproductive wood and renew the actively growing branches which can support sufficient volume of maintenance foliage on it.

Pruning is usually done after every three to four years at 3 - 4 cm above the previous pruning mark: it is generally described as **Light Prune** (L. P.). But when the bush frame grows more and plucking becomes difficult, it is brought down to optimum height by **Medium Prune** (M. P.) at 50 - 70 cm above the ground.

3.4 Manufacturing Process

Once the tea leaves are plucked from the garden and transported to the factory, it goes through various stages in factory. All the processes involved in the tea processing play an important role in building the quality of tea. Careful and proper processing normally bring out the full potential of the green leaf. The processes involved in the manufacturing of tea are (The Planter's Handbook, TRA):-

1. Withering **2. C.T.C./Orthodox Process** **3. Fermentation**
4. Drying **5. Sorting & Packaging**

Fig 3.2 shows the steps of tea manufacturing process.

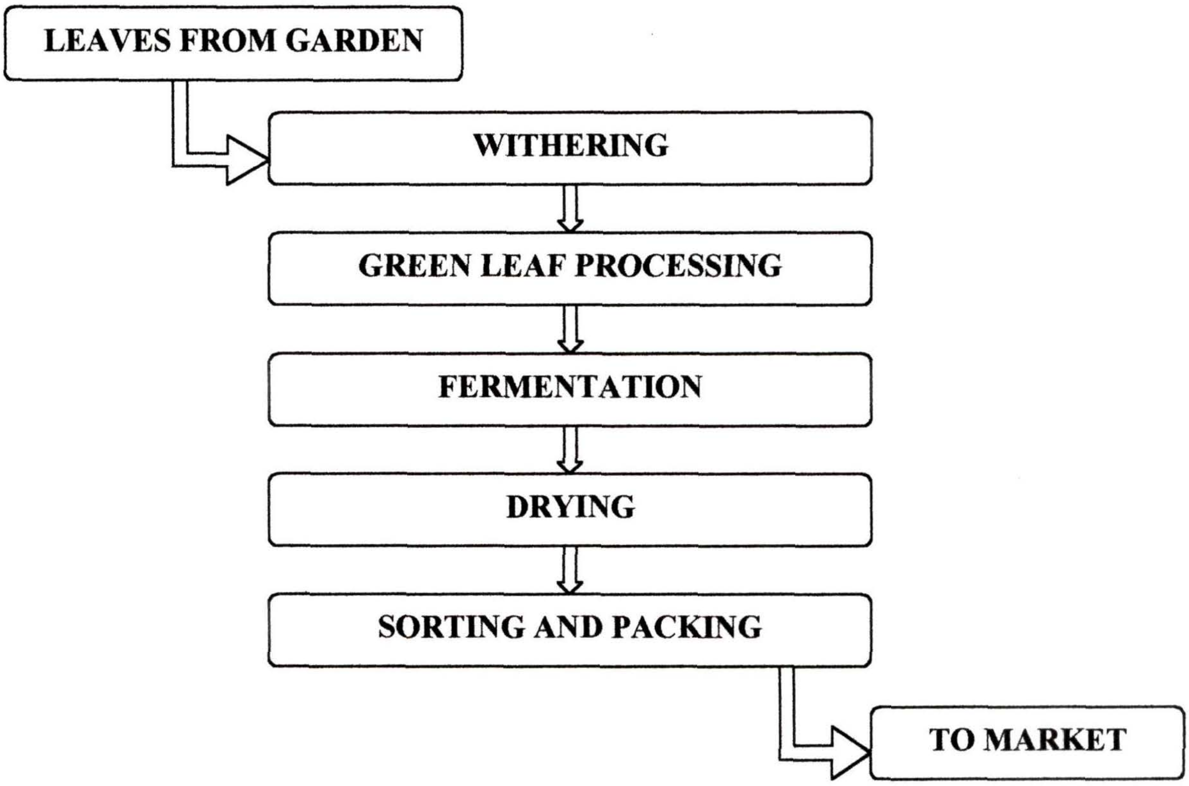


Figure 3.2
Processes Involved in Tea Manufacturing

3.4.1. Withering

Withering is the first process carried out within the factory on the plucked tea leaves. The fresh plucked leaves after sorting are placed on the withering troughs and air is allowed to pass over the leaves. The air fans which are used in this process are called 'withering fans'. The process of wither aims at partial removal of moisture from the fresh leaf. It is carried out in order to condition the leaf physically for subsequent processing. Besides, some chemical changes also take place during withering and these are independent of the physical process. The process of withering involves:-

Photograph 2
Sorting of Fresh Leaves

1. Physical Wither 2. Chemical Wither

3.4.1.1 Physical Wither

During physical wither the leaf loses its moisture and hence turgidity which makes the leaves flaccid or rubbery, a most desirable condition to help in its rolling and for obtaining the desired style and appearance. The extent to which the wither is to be carried out will depend upon the method of manufacture. Under the North East Indian conditions the norms usually adopted are given in Table 3.1(The Planter's Handbook, TRA):-

Photograph 3
Withering Troughs

Table 3.1
Percent Wither in Different Types of Tea Manufacture

Method of Manufacture	Wither (% - Percent)
CTC	70-72
Orthodox	65-68
Dual	67-69

[% wither = The weight of 100 Kg of fresh leaf at the end of the withering process]

3.4.1.2 Chemical Wither

Chemical wither starts immediately after leaf is detached from the plant. It is independent of the rate of loss of moisture and is the function of time and temperature. Following chemical changes occur within the leaf cells.(Khanna, A.I.N. 1999 & Gogoi, M.N., 1999)

1. Breakdown of larger molecules to smaller ones that results in the increase of contents of amino acids and flavor compound
2. Increase in caffeine which is responsible for the stimulant effect of tea.
3. Increase in permeability of cell membranes which has a great effect on the mixing of polyphenols, enzymes and oxygen for even fermentation.

3.4.2 Green Leaf Processing

Green leaf processing is that step in the process of tea manufacture where the withered leaf is subjected to some kind of mechanical operation whereby the leaf cells are ruptured to give the desired style and appearance to the made tea. During this operation the leaf undergoes the process of size reduction with a degree of cell disruption to allow the exposure of new surfaces to air during the fermentation process. Fig 3.3 shows the processes involved in black tea manufacturing (both Orthodox and CTC).

3.4.2.1 Orthodox Manufacture

In the conventional orthodox process, the leaf distortion is achieved by rolling, during which the withered leaf is subjected to the motions of conventional rolling machine. The purpose of rolling is to primarily break up the leaf cells and to mix up the chemical components of the leaves with the enzymes. In orthodox method of manufacture, these chemical constituents are 'wrung' out by subjecting the leaves to twisting or 'rolling' that imparts the leaf a twisted appearance and a special character to the liquor of made tea.

The simultaneous twisting and rupturing of the leaf cells allow the chemical contents of the leaf to be mixed up in presence of air (i.e. oxygen). This starts off the chemical changes necessary for production of black tea characteristics through the fermentation process. During rolling, tender leaf parts are torn off, leaves are detached, stalks are broken up into smaller parts, and the leaf juice is forced to come over the surface of the broken leaf particles. The expression of juice is dependent on the physical condition of the leaf after wither during which the cell membranes become more permeable. The thorough mixing of the catechins present in leaf and the enzyme under exposure to oxygen facilitate initiation of the fermentation process.

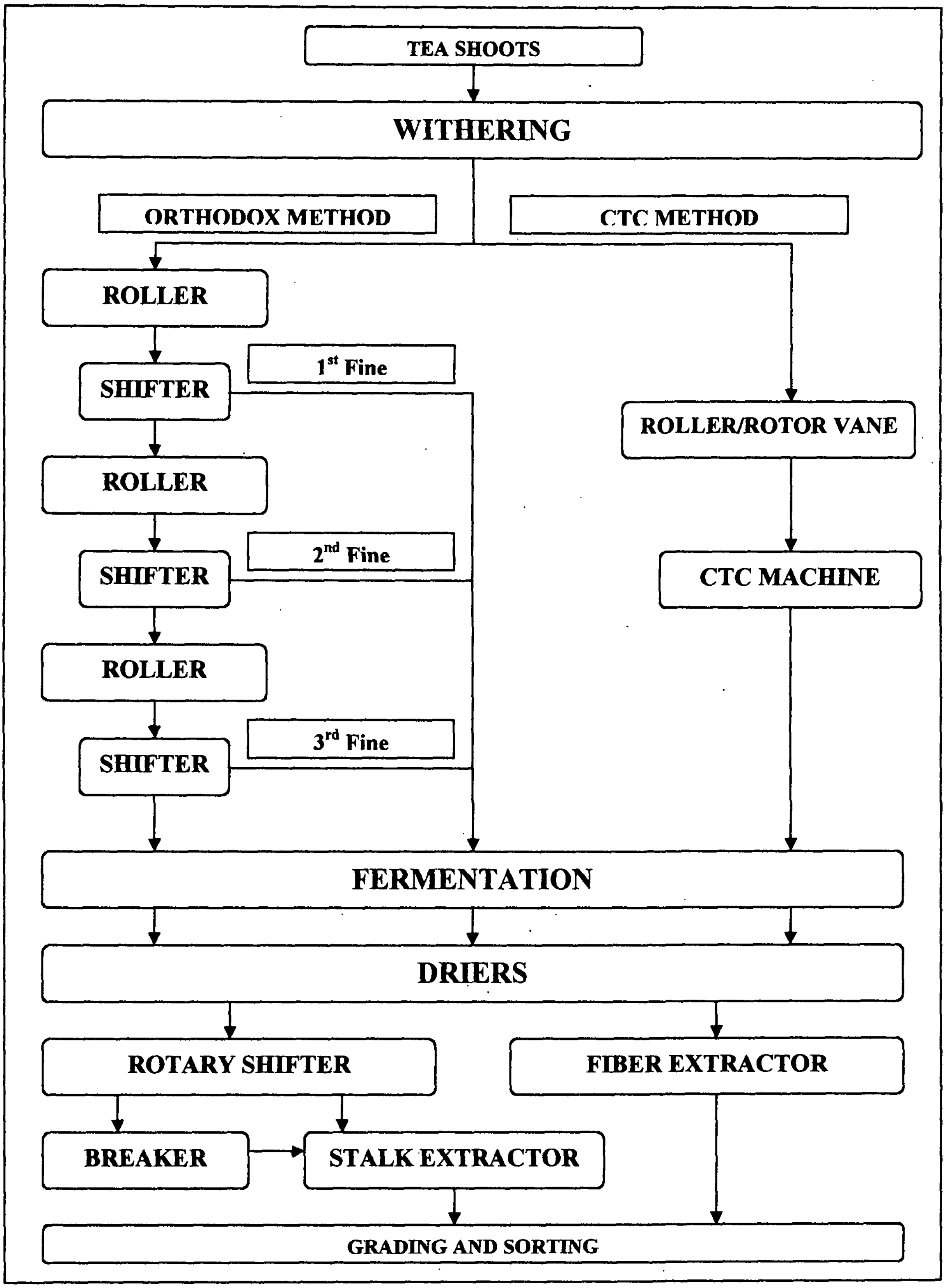


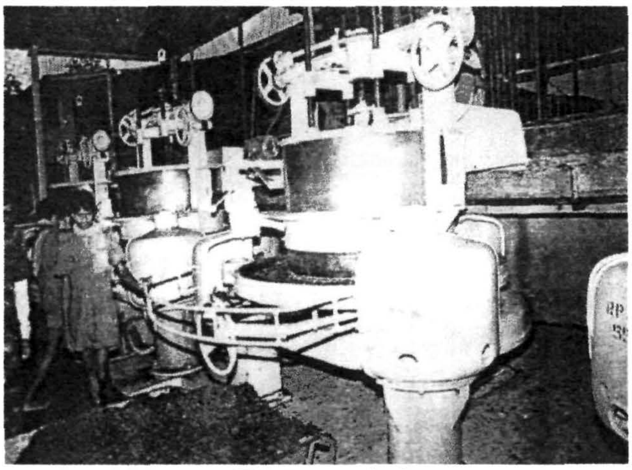
Figure 3.3
Processes Involved in Black Tea Manufacturing

The twisted appearance in the leaf during the rolling process can be imparted with a lighter roll in a rolling table with very little breaking up of the leaf into pieces. Hard rolling on the other hand breaks the leaf into small pieces with little rolled appearance in the product. For the sake of efficiency of brewing, the orthodox tea traded all over the world comprises of small leaf particles with leaf juice dried on its surface. The requirement of the rolling machine as well as the process is, therefore, a compromise between the twisted appearance and liquor.

The number of rolls and the period of rolling are dependent on the following factors (Tankariwala.N.F, 1999):

1. Type of leaf.
2. Degree of wither.
3. Roller charge and speed
4. Pressure.
5. Temperature.
6. Type of tea required.

Generally a roll of 20-30 minutes is given in the orthodox roller without or with light pressure, and the leaf is then passed through a shifter to extract fines. The length of rolling varies from factory to factory, but it should not be shorter than 15 minutes to avoid formation of flaky leaf appearance. The question whether two or three passes (Refer Fig: 3.3) are necessary is usually decided by the plucking standard and the withering facilities prevailing in a particular factory. With fine plucking two passes through Rollers are known to have yielded desired results, but with coarse plucking third cut may be necessary.



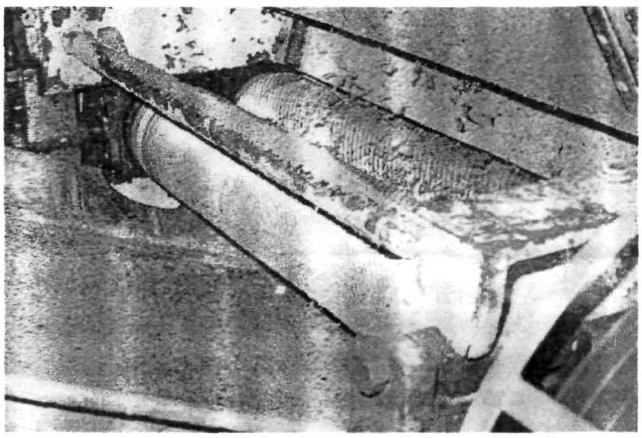
Photograph 4
Rolling Machine

3.4.2.2 C.T.C. Manufacture

The CTC (crushing, tearing and curling) manufacture is the contribution from Sir William Mckercher, an ex-Superintendent of Amgoorie T.E., Assam (Griffits.P, 1977). He invented the CTC machine in 1930. The CTC machine consists of two stainless steel engraved rollers with circumferential helical grooves. They are meshed closely and made to rotate in opposite directions at a speed differential of 1:10. The rolled leaves are allowed to pass through the zone between the two rollers. The teeth of the rollers perform the crushing tearing and cutting operations simultaneously. The following three parts of a tooth are responsible for the CTC process.

The '**Tooth Body**' or shoulder length is responsible for crushing. The '**Milling Groove**' which creates the flanks of the teeth helps in curling of the leaf. The '**Sharp Edges**' of the teeth are responsible for cutting and tearing of the leaf.

Processing of leaf in a CTC machine requires that the leaf be rolled or conditioned prior to feeding in the CTC machine. Therefore, the rolling table has to be used which is to be synchronized to be able to feed the CTC machine continuously. Meanwhile, Rotorvane, invented at Tocklai initially as continuous roller, proved to be an ideal machine for rolling/conditioning the leaf for CTC manufacture. The throughput through a 15inch rotorvane varies between 550-1600 kg of processed leaf per hour. Its speed varies from 15 to 45 rpm. The throughput is 37 kg of processed leaf per hour. Thus with good plucking standard the capacity of a 15 inch rotorvane matches with that of a 36 inch CTC machine.



Photograph 5
CTC Machine

3.4.2.3 Dual Manufacture

Though CTC machine was developed in 1930, it did not catch on for next two decades because the early users failed to produce quality CTC tea as they did not shorten the time for fermentation. (Dutta. A.K., 1992). Thus the CTC manufacturing method commercially started in the fifties. After just ten years of time, more than two-thirds of the Teas manufactured were CTC tea. It was however; observed that from time to time there has been a greater demand for Orthodox tea. This led to the development of a new concept of tea manufacture popularly known as dual manufacture. The attractive benefit derived from this process in that: the fines, containing much of the valued tips are extracted from the normally rolled leaf and subsequently fermented and fired conventionally, while the coarse leaf is put through a CTC machine. This method of manufacture has been carried out by the industry with mixed leaf i.e. clones and jats as well as from only seed jats. However, some estates adopt the method of dual manufacture at a particular season depending upon the market demand.

3.4.3 Fermentation

Fermentation of tea is the most significant step in tea manufacturing since in this step the most important properties of tea i.e. liquor characteristic develops. The term 'fermentation' is rather historical and does not accurately describe the process that occurs during the manufacture of black tea. This process involves enzymic oxidation/ degradation of polyphenols, lipids, carotenoids and tarpene- glycosides , and their subsequent condensation/degradation leading to formation of coloured polymers and aroma and flavor compounds. (Goswami et al., 1999)

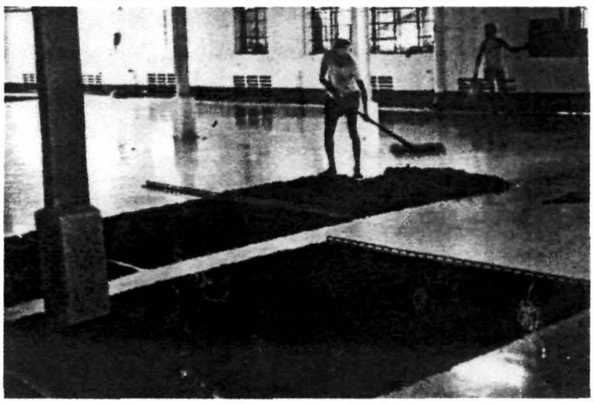
Fermentation of leaf begins with its rolling to bring about the necessary changes to make tea liquor palatable. The complex changes occurring during fermentation, in which the polyphenols are oxidized and other associated chemicals also undergo some changes, make the liquor develop mellow character. Under optimum condition of fermentation, the liquor becomes bright and brisk with adequate colour and strength. These attributes of quality develop only upto a certain stage of fermentation beyond which the quality begins to decline.

3.4.3.1 Development of Color and Quality During Fermentation

Various liquoring qualities of tea are mainly derived from the same group of chemical compounds. Therefore, the excessive production of one property will naturally take place at the expense of another. Briskness, quality, strength and colour change with time and temperature during fermentation and each character is at its best at different times (Goswami et al., 1999). In under-fermented tea the leaf yields poor liquor and hence less quality, but well fermented leaf will give good colour. Over-fermented leaf may produce coloury liquor, no briskness and very poor quality. Only optimum fermentation ensures strength, brightness, briskness and quality of the liquor.

3.4.3.2 Fermentation System

The common fermentation systems practised in tea manufacture are described below:-



Photograph 6
Floor Fermentation

3.4.3.2a Floor fermentation

Fermentation on cement floor is the oldest and most popular method. Leaf is spread over cement floor of racks at 2.5-3.75 cm thickness for orthodox and 1.25 cm in case of CTC tea. The floor should not be wet when the leaf is being spread and there should never be any stale juice deposits. This will help to keep the bacteria away. Washing of the floor daily with a suitable detergent is absolutely necessary. Floors with glazed marble tiles are also used but care should be taken that the joints between tiles do not become the source of bacterial contamination. Aluminum and plastics trays are sometimes used for fermentation. Leaf spread over the trays should be sprayed thin so that proper aeration can take place. Only plain aluminum or plastic sheets should be used to avoid bacterial contamination

3.4.3.2b Trough fermentation

In trough fermentation, troughs made of aluminum are placed on saddle to facilitate uniform distribution of air. Rubber or fads lining are used as pads on the fermenting units to prevent air leakage. Two types of *gumlas* (shallow large container without lid) are used, one with valves and the other with four holes at the bottom. The air pressure should be maintained at 2 inch water gauge. Fermenting containers do not work well with the under withered leaf.

Trough fermentation is more controllable because the quantity of air flow and the pressure can be adjusted. It also cuts down the total surface area required. A 15 cm deep container can hold up to 16 kg of pressed leaves when filled to the top .However, the containers are not filled to the top level so as to facilitate turning of leaves as and when required.

In trough fermentation the temperature encountered is high but experimental results have shown that even at temperature up to 43° C is not harmful to quality if adequate amount of humidified air is used to pass through the leaf bed and the fermentation time is cut down.

3.4.4 Drying

Drying is the final stage of manufacturing of tea. During drying the moisture is removed from the fermented leaf particles in a suitable chamber by vaporization of water in a stream of hot air as the carrier fluid. Drying is a simultaneous heat and mass transfer process – gain in temperature or heat, loss in moisture or mass. Air in warmed up condition and in adequate quantity is the most convenient medium for heat and mass transfer during tea drying.

The objective of drying of tea is two fold.

1. To arrest the fermentation and to fix the desirable properties.
2. To remove the moisture from the leaf particles and to obtain a finished product that is stable which can be handled and transported.

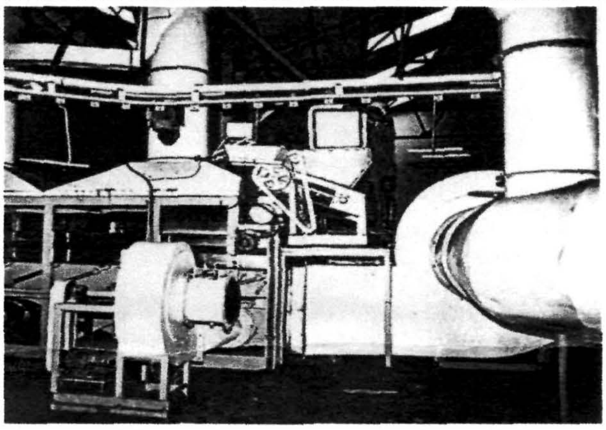
3.4.4.1 Technology of Tea Drying

When a particle is surrounded by moisture molecules in its surface, the removal of these moisture is relatively easy and such evaporation rate is independent of the properties of the particles. This rate of evaporation is governed by the mass flow rate and drying potential of air only. In the drying process this stage is known as ' Constant Rate

Period' of drying. (Chaliha. R[2], 1984)

With the removal of freely available water from the surface of the solid particle, a stage is reached where some portions of the particles surface would be devoid of any moisture molecules and the balance would still have some. The rate of drying of such particles will continuously decrease and drying will become increasingly more difficult. Once the surface drying is complete, diffusion processes control the drying rates. Those moisture molecules entrapped inside the particles have to come out to the surface either in liquid or in vapour form before leaving the tea granule. As the moisture level of the particles decreases, the concentration gradient decreases too reducing the rate of drying. This stage of drying is known as the ' Falling Rate Period' of drying. The critical moisture content at which the rate of drying slows down depends on the size and shape of the solid particles and their texture.

Early types of dryers were simple batch types, in which the leaf was spread on a perforated mesh or tray and heated air blown through until the tea was dried. A semi-continuous system employing a series of trays mounted horizontally on a vertical stack was constructed. Sequential mechanical tripping was employed to drop the contents of each tray at selected intervals onto the tray immediately below. Hot air was fed from below and the dried tea eventually emerged at the lowest point. These dryers known as Venetian dryers are not in use now-a-days.



Photograph 7
Tea Dryer

The modern machine consists of two or three endless chains where perforated trays are mounted. In the present design the drier is situated on the pressure side of the fan, but in the earlier versions the fans sucked air through the drier. Fermented leaf is dropped on the top tray of the drier by a conveyer. The leaf particles falling on the perforated tray are taken through the drier by the moving trap. At the end of each tray level the leaf is dropped to the tray immediately below. Hot air is sent from the bottom of the drier and is made to flow up through the perforations. The arrangement ensures progressively higher temperature during the course of drying and the air is made to come in contact with the increasingly moist leaf particles.

A tea drier consists of the dryer unit, the air heater and the fan. The hot air is provided by a furnace to which are connected the heat exchangers. An induced drought is maintained by the fan. The fermented tea particles, when ready for drying, are regularly fed into a hopper with automatic spreader. Thickness of spread, speed of trays and the volume of air flow through the trays are regulated as desired. As is clear from the design at each stage of drying, the leaf is subjected to a different temperature. The exhaust temperature should be such that the fermentation process is brought to a stop immediately after the leaf has entered to the top tray of the dryer. However, in actual practice the fermentation, which is enzymic in nature, continues for some time in the dryer.

3.4.5 Sorting & Packaging

After the tea has been dried, its separation into grades is necessary in order to produce tea which will be acceptable to buyers and blenders. Separation of tea particles according to various shapes and sizes conforming to trade requirement involves many operations. Machine sorting alone is not enough. Hand sieves have to be used. The whole procedure is long and laborious when a large number of grades are made. This, on account of variations of leaves and methods of manufacture, varies considerably in different factories.

Photograph 8
Sorting of Tea

It is one process in manufacture for which no hard and fast rules are laid down. Careful judgment is required to decide whether or not a grade is true to the type and whether it is sufficiently uniform and free from fiber, stalk, etc. Such consideration necessitates a considerable amount of skill, care, and attention. A sorting procedure, that may suit one factory, may therefore prove unsuccessful in another. Tea is sorted for quality and size. There are four main sizes viz. Whole Leaf Grades, Brokens, Fannings and Dusts. Each of these has their sub-grades.

For various reasons, often it is not desirable to divide the tea into the greatest possible number of grades. The percentage of leaf suitable for the production of some of the grades is small and it may take too long to collect sufficient quantity of these to make a large invoice to attract attention in the market. Tea grading percentage must of course vary according to plucking standards and the market demand. The different marketable grades of tea are given in Table 3.2.

3.4.5.1 Sorting of Orthodox Tea

The dried tea is initially passed through a Myddelton Stalk Extractor. The Myddeltons are fitted with trays. The top and bottom trays of Myddelton are so adjusted that only broken grades are removed. These feed directly into the sorter conveniently sited near the Myddelton. The bottom tray of the Myddelton contains mainly whole leaf grades and these feed into wire mesh having no. 12, 10, 8 and 6 meshes. The spill goes to the breaker cum stalk separator machine. From the breaker the mass go to a Myddelton. From the top tray of Myddelton the mass will go to a ***pucca*** sorter and the broken grades are obtained. From the bottom tray of Myddelton the smaller grades will be obtained through another ***pucca*** sorter.

3.4.5.2 Sorting of C.T.C. Tea

The CTC bulk mass is passed through a fiber extractor and a presorter. From the presorter the larger leaf goes to a sorting machine from where the broken grades are obtained. Medium sized particles go to another sorting machine to give fannings. Likewise the smaller particles go to a third sorting machine from where dust grades will be obtained. Fig 3.4 shows the process.

Table 3.2
Different Grades of Tea

Kind of Tea	Grade Name	Nomenclature	Kind of Tea	Grade Name	Nomenclature	Kind of Tea	Grade Name	Nomenclature
Orthodox Tea			**C.T.C. Tea**			**Green Tea**		
	FTGFOP	Fine, tippy golden flowery orange pekoe						
	TGFOP	Tippy golden flowery orange pekoe		BOP	Broken orange pekoe			
Whole leaf	TGFOP 1	Tippy golden flowery orange pekoe one	Broken	BP	Broken pekoe	Whole	YH	Young hyson
	GFOP	Golden flowery orange pekoe		BPS	Broken pekoe souchang	leaf	FYH	Fine young hyson
	FOP	Flowery orange pekoe						
	OP	Orange pekoe		OF	Orange fannings			
			Fannings	PF	Pekoe fannings	Broken	GP	Gun powder
	GFBOP	Golden flowery broken orange pekoe		PF 1	Pekoe fannings one		H	Hyson
	FBOP	Flowery broken orange pekoe						
Broken	GBOP	Golden broken orange pekoe		PD	Pekoe dust			
	BOP 1	Broken orange pekoe one	Dust	D	Dust	Fannings	FH	Fine hyson
	BPS	Broken pekoe souchang		CD	Churamoni dust		Soumea	Soumea
				PD 1	Pekoe dust one			
	GOF	Golden orange fannings		D 1	Dust one	Dust	Dust	Dust
Fannings	FOF	Flowery orange fannings		RD	Red dust			
	BOPF	Broken orange pekoe fannings		FD	Fine dust			
	OF	Orange fannings						
	OPD	Orthodox pekoe dust						
Dusts	OD	Orthodox dust						
	OCD	Orthodox churamoni dust						
	FD	Fine dust						

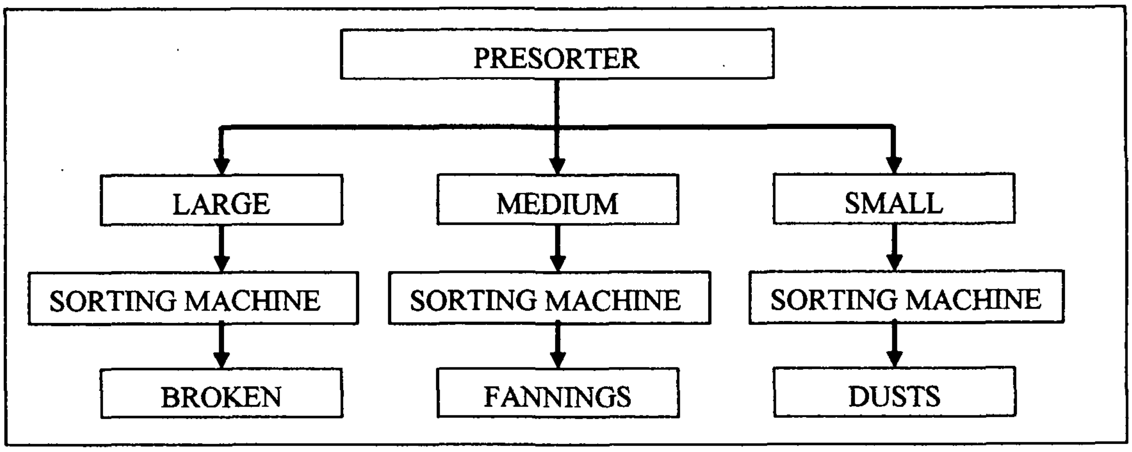


Figure 3.4
CTC Fiber Extractor and Combinations

Table 3.3 shows the sizes of the sorting trays.

Table 3.3
Sorting Trays and Various Combinations

THORUGH TOP TRAY	THROUGH BOTTOM TRAY
Through No.10 mesh over 12-BOP 1	Through No. 22 mesh over 24-FOF/GOF
Through No. 12 mesh over 14-BP	Through No. 24 mesh over 26-PF
Through No. 14 mesh over 16-FBOP	Through No. 28 mesh over 30-OPD
Through No. 16 mesh over 18-GBOP	Through No. 30 mesh over 40-OD
Through No. 18 mesh over 20-GFBOP	Through No. 40 mesh over 60-OCD

3.4.5.3 Packaging

After the tea has been sorted into respective grades, it is necessary to pack these in suitable packages/sacks so that the quality of made tea does not deteriorate in transit. Tea is packed by packing machines having magnetic attachment to prevent possible pieces of iron metal fillings from mixing with tea. Efforts are made to prevent tea from absorbing moisture. Tea chests used for packing tea are moisture-proof.

In most of the tea gardens in Assam, the present mode of packing is not absolutely air-tight and as a result tea absorbs more than 3% moisture by the time it reaches market. It has been found that plywood tea chests with lining of alumina and tissue paper, metalized polyester or cellophane are suitable for packing tea. (Das, A.K., 1999)

Chapter IV

Factors Affecting Quality of Tea: A Model

4.1 Tea Quality

The term 'Tea Quality' in its broadest sense for made tea is used as a description of all the characteristics viz., appearance, cup-characteristics or in other words liquoring qualities such as colour, brightness, strength, aroma and finally characteristics of infused leaf which determine its market value. So, in general, evaluating tea quality means a summation of the desirable attributes comprising internal and external characteristics. (Garodia, P.; 1979)

In trade circle the term quality for made tea is commonly used to indicate the presence of some special desirable characteristics in the liquor. In this sense, the term quality of a cup of Tea is partly sensation in the mouth, partly an aroma and partly the appearance.

4.2 Exploration of Factors Affecting Tea Quality

Here an attempt has been made to investigate and analyze the process of tea production in tea gardens with an objective of improving the quality of made tea.

In such an attempt, it is essential to make an assessment of the factors affecting the quality of tea. In addition to the survey of literature, several visits were made to a garden in Assam that produces premium tea in terms of auction price, to assess the factors affecting the quality of tea. Moreover, small tea growers, experts from Tocklai Tea Research Association, Jorhat (Assam), Assam Agricultural University, Jorhat (Assam) were also consulted while developing the causality model.

Thus, the factors which affect the tea quality were determined by:

- extracting knowledge of the managerial level people, supervisors, workers of the tea gardens through systematic Questionnaire Survey
- investigative conversation with the people related to tea industry
- extensive study of literature on the subject

Based on the findings, the factors affecting the quality of tea are classified into eight categories:

1. Genetic Factors
2. Environmental Factors

3. Cultural Factors
4. Leaf treatment Factors
5. Factory Hygiene Factors
6. Maintenance Factors
7. Labour Factors
8. Processing Factors

4.2.1 Genetic Factors

The tea quality determined by the genetic properties is based on the chemical composition of the leaf, such as Polyphenol content, Protein nitrogen component, Leaf pubescence, Planting Materials, etc. (Baneerjee. B.[2]; 1993)

The polyphenolic group makes up about 30% of the solid matter of the tea shoot. The polyphenols are popularly known as tannins, although they have no tanning properties. The polyphenolic bodies in tea shoot decrease in quality from bud to stalk. A sample of shoots of Assam leaf, for instance, shows that the polyphenols make about 35% of dry matter in the bud and first leaf, 28% in the second leaf and 15% in the stalk with a total polyphenolic content of the shoots of 30%.

The quantity and proportion of polyphenols present in green leaf generally is reflected in the chemical composition of the made tea in the liquor characteristics. The colour, strength and pungency of the infusion in the fermented black tea depend mostly on the polyphenolic content. The greater the polyphenolic content the greater are the Briskness, Strength and Colour.

A high content of caffeine is one of the factors indicating a good quality tea. Maximum caffeine content is found in the newly formed leafs and buds. The coarser leaves and stem have lower caffeine content.

Proteins combine with the oxidation products of fermentation and lead to insoluble products which are harmful from the quality point of view of tea. So, high protein content in the leaf is an undesirable factor. (Dhan. I.K.; 1995)

The tea made from pubescent leaves (leaves without hairs) and buds are superior to the tea made from leaf with hairs. Polyphenols, Caffeine and Carbonyl compounds are present in greater amounts in the hairy leaves than in non hairy leaves. The Carbonyl compound increases the flavour of the tea.

Since the best possible tea cannot be made without the best leaf, so due attention should be paid to the genetic properties of the leaf and with it to the planting materials for new tea plantings. Choice of proper tea clone is the first step towards a brighter future of a garden. (Das S.C. et al., 2002)

The genetic properties of the leaf vary from country to country, from plantation to plantation, from field to field and even from bush to bush. The genetic factors affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig 4.1.

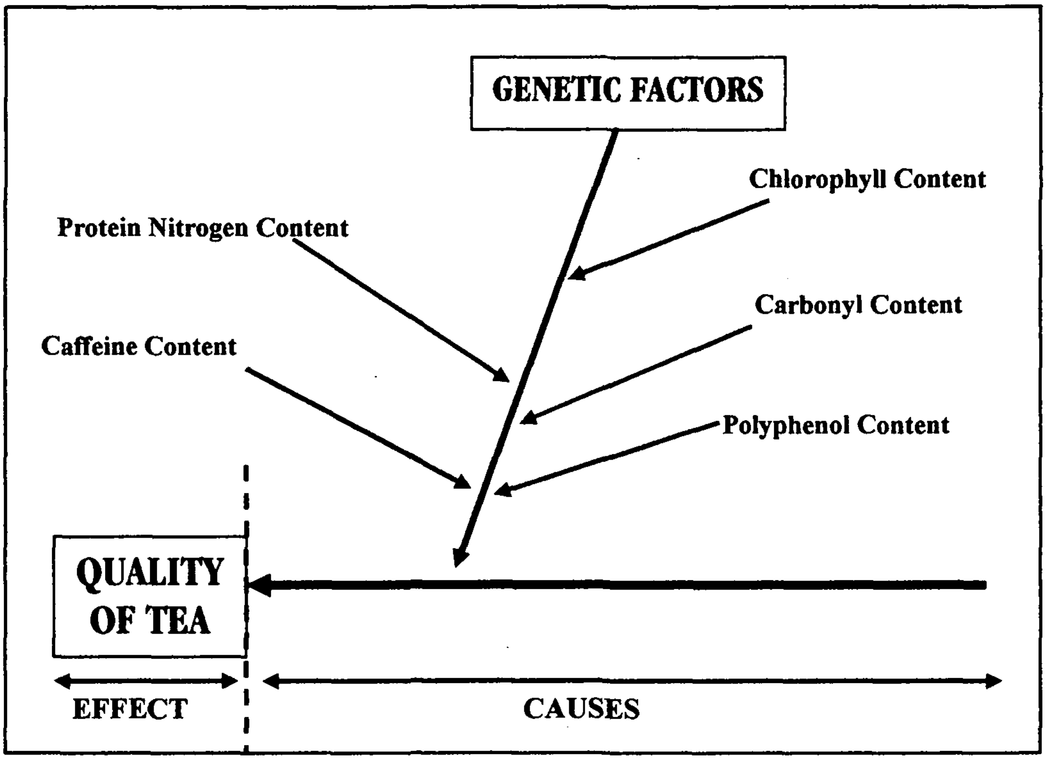


Fig 4.1
The Genetic Factors Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4.2

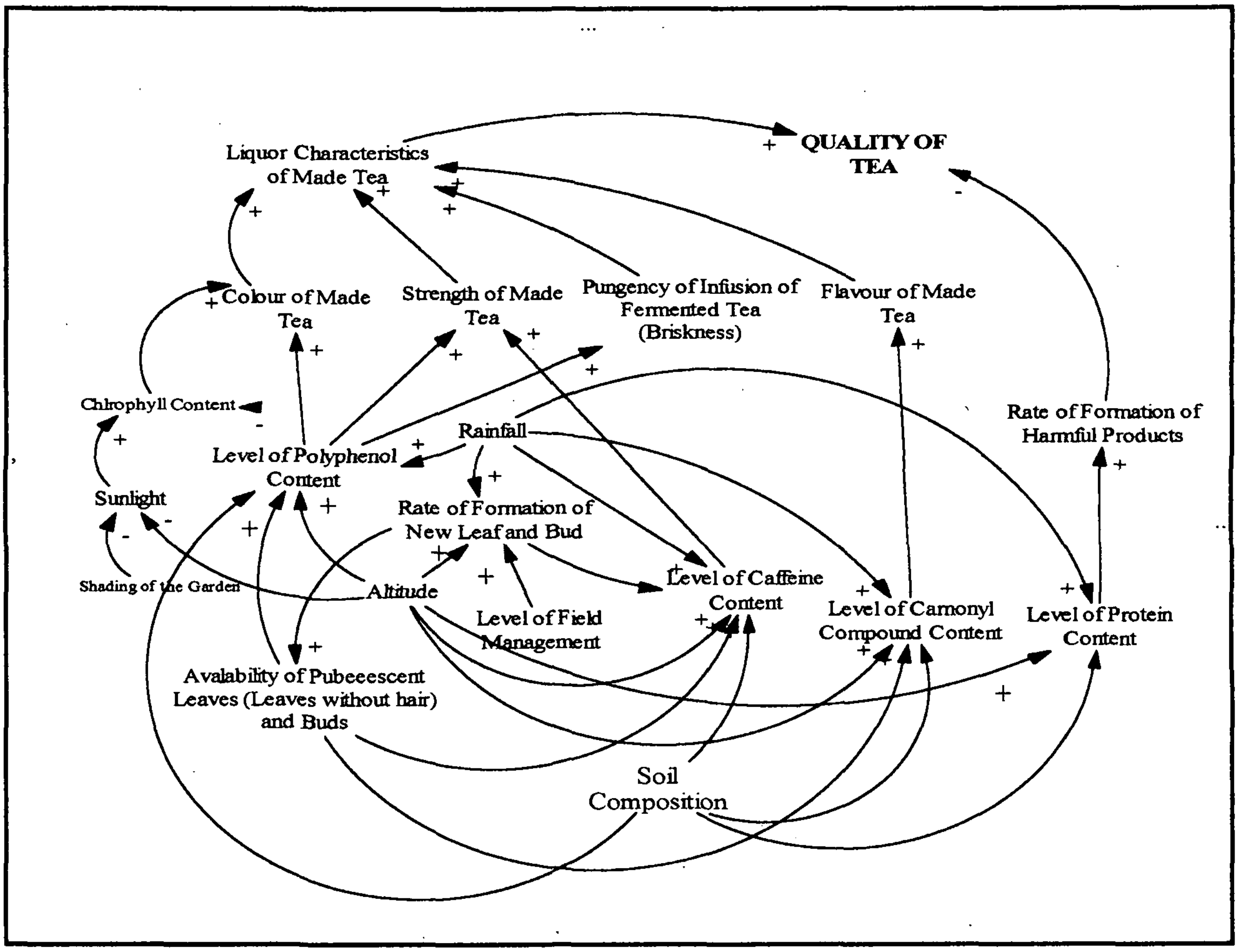


Fig 4.2
Causal Relationship among the Genetic Factors Affecting Quality of Tea

4.2.2 Environmental Factors

The environmental conditions affect the natural growth of the tea plants, their composition and leaf characters thus show a great effect on the quality of the tea.

Both soil and climate affect the tea quality but especially the climatic conditions including Temperature, Air humidity, Sunshine, Rainfall and Day length are of importance. Soil pH, bulk density of soil, soil temperature, soil tillage, moisture content of soil, organic carbon content of soil affects the volume and quality of tea production. (Barooah et al[1], 2002)

Tea made from second flush (dry season) in Assam valley have higher concentration of the important constituents in the leaf which are responsible for high quality tea than the tea produced in the rainy season. The areas with well-distributed rainfall and uniform temperature result in even growth and regular cropping, where the productivity is generally high but tea quality is moderate to low.

High altitude plantation tea leaves results in the production of made tea of high quality and outstanding flavour. Tea produced at higher altitudes is of better quality than medium or low grown tea. This is due to lower temperatures at higher elevations and to the corresponding slower growth as polyphenol contents are found to be higher in the period of slower growth under conditions of dry weather and ample sunshine.

Experiments conducted in Sri Lanka, Java and Sumatra showed that leaf grown at a lower elevation, but processed in factories at higher altitudes gave teas of improved quality, brighter liquor and brighter infused leaf. (Barua, P.C.; 1984)

Chlorophyll plays an important role in the formation of colour of the made tea. The chlorophyll formation depends on sunlight and so its content varies with environmental conditions like altitudes, shade and other factors. Low grown leaf and rainy season leaf contain more chlorophyll and the tea made from such leaves are therefore blacker than those produced from high grown leaf and dry season leaf.

The Causal relationships of the environmental factors are shown in Fig. 4.3

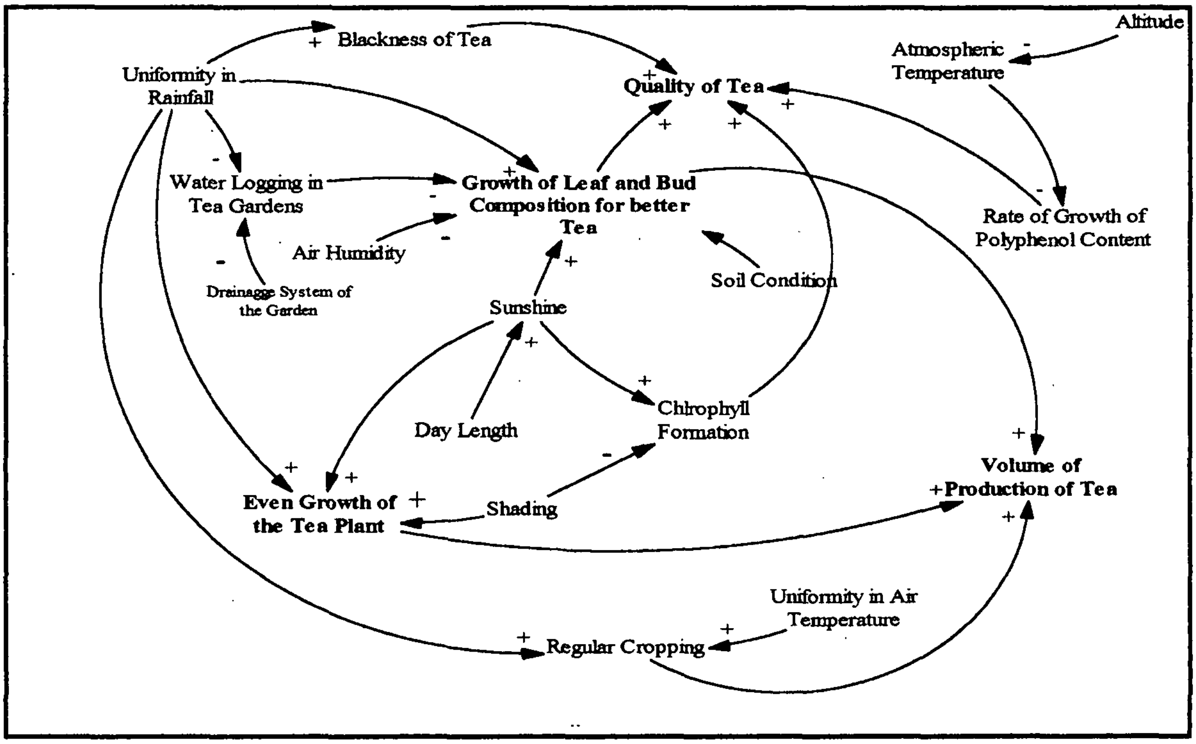


Fig 4.3
Causal Relationship among the Environmental Factors Affecting Quality of Tea

4.2.3 Cultural Factors

Cultural factors represent the plantation practice of a garden. These factors include: Standard of plucking, Fertilizing, Shading, Pruning, Irrigation, Pest management, etc.

Good tea is the product of good leaf in the first place. Since the quality of tea depends upon the composition of the plucked leaf, it is indirectly affected by the plucking interval. Plucking should be carried out at such interval (7-10 days), so that no too many shoots left from the previous round are plucked in an overgrown stage, nor too few shoots have developed in the mean time to make plucking worthwhile. Flush shoots of two leaves and a bud obtained by fine plucking ('two leaves and a bud') are the best material, because of the high contents of polyphenols and caffeine. Further more, the physical property of fine leaf is most suitable for processing into good tea.

Since the objective of plucking is the commercial production of high quality tea at the highest possible level throughout the life time of a tea plant, plucking and other measures of bush management should be carried out efficiently. Not only adequate leaf of good standard should be plucked, but sufficient mature leaf should be left on the bush.

Bud and first leaf are the richest sources of polyphenols and caffeine; the leaves lower down and the stems are proportionally poorer in these constituents.

Leaf plucked in the morning produces better tea than leaf plucked in the evening. This is caused by higher polyphenol content produce from sugars and by higher amino-acid content produced from proteins during the night. Another cause is the better leaf plucking in the morning compared to careless plucking in the afternoon.

Under some environmental conditions, shading increases the yield and quality of tea while in some other environmental conditions it has a depressing effect on quality.

Findings in Japan show that the tea grown under shade have low polyphenol content, which affect the quality. In Assam, shade is beneficial and is even necessary for successful cultivation of tea. In Assam, shade reduces the natural light intensity by about 50% and usually increases the yield, but it does not affect tea quality adversely (Phukan, B. C., 2002 and Barthakur et al., 2002).

In general, possibly related to changes in the growth rhythm of the bush, the quality of tea is affected by the age of pruning. Generally tea quality improves with higher age both for planting and pruning. Leaves harvested directly after pruning is large and watery, low in polyphenol contents and high in nitrogen content .Experimental studies in the field of pruning say that with a shorter pruning cycle, a better colour and strength of tea are obtained. Tea obtained from gardens younger than fifteen years are of lower quality than tea from older gardens.

The Causal relationships of cultural factors are shown in Fig. 4.4

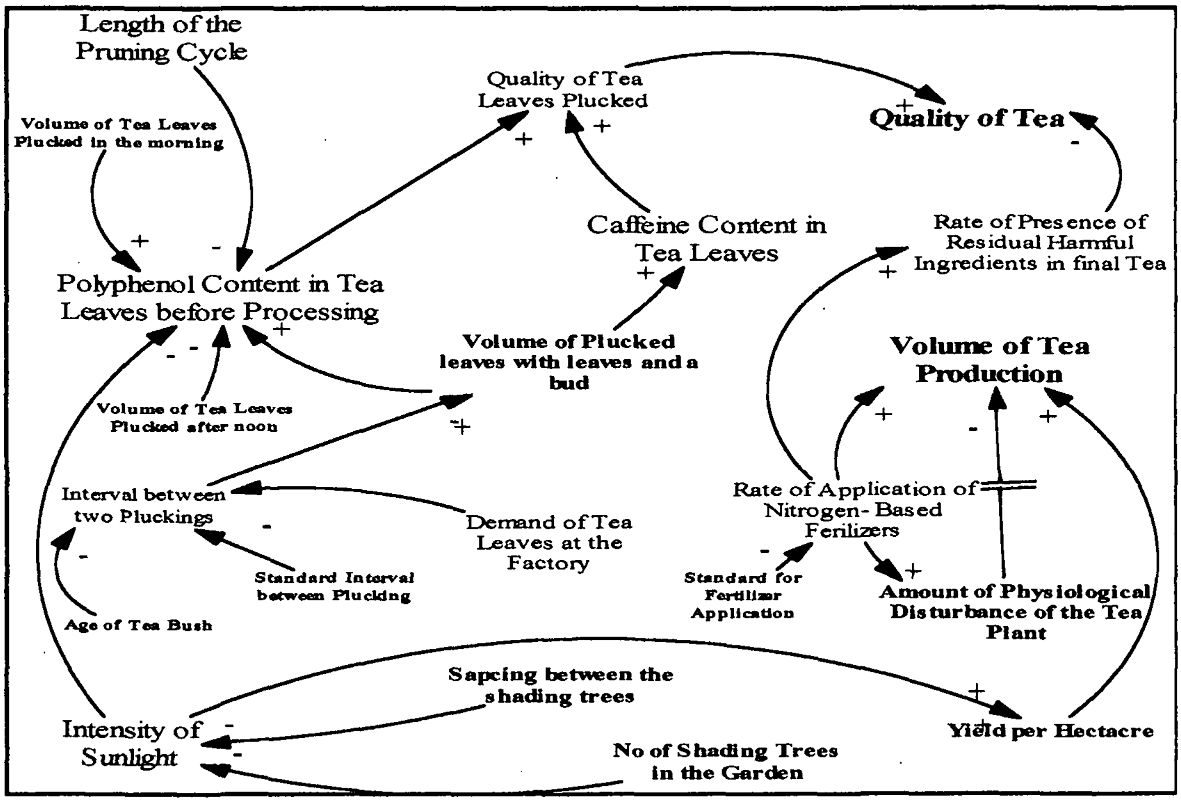


Fig 4.4
Causal Relationship among the Cultural Factors Affecting Quality of Tea

The combined Ishikawa Cause and Effect diagram for Environmental and Cultural factors are shown in Fig. 4.5

4.2.4 Leaf Treatment Factors

One of the important tasks in maintaining quality of tea is the careful handling of green leaf. For best results in the factory due care and attention should be given to the green leaf both in field, during transport and before withering. Care should be taken in the following areas:

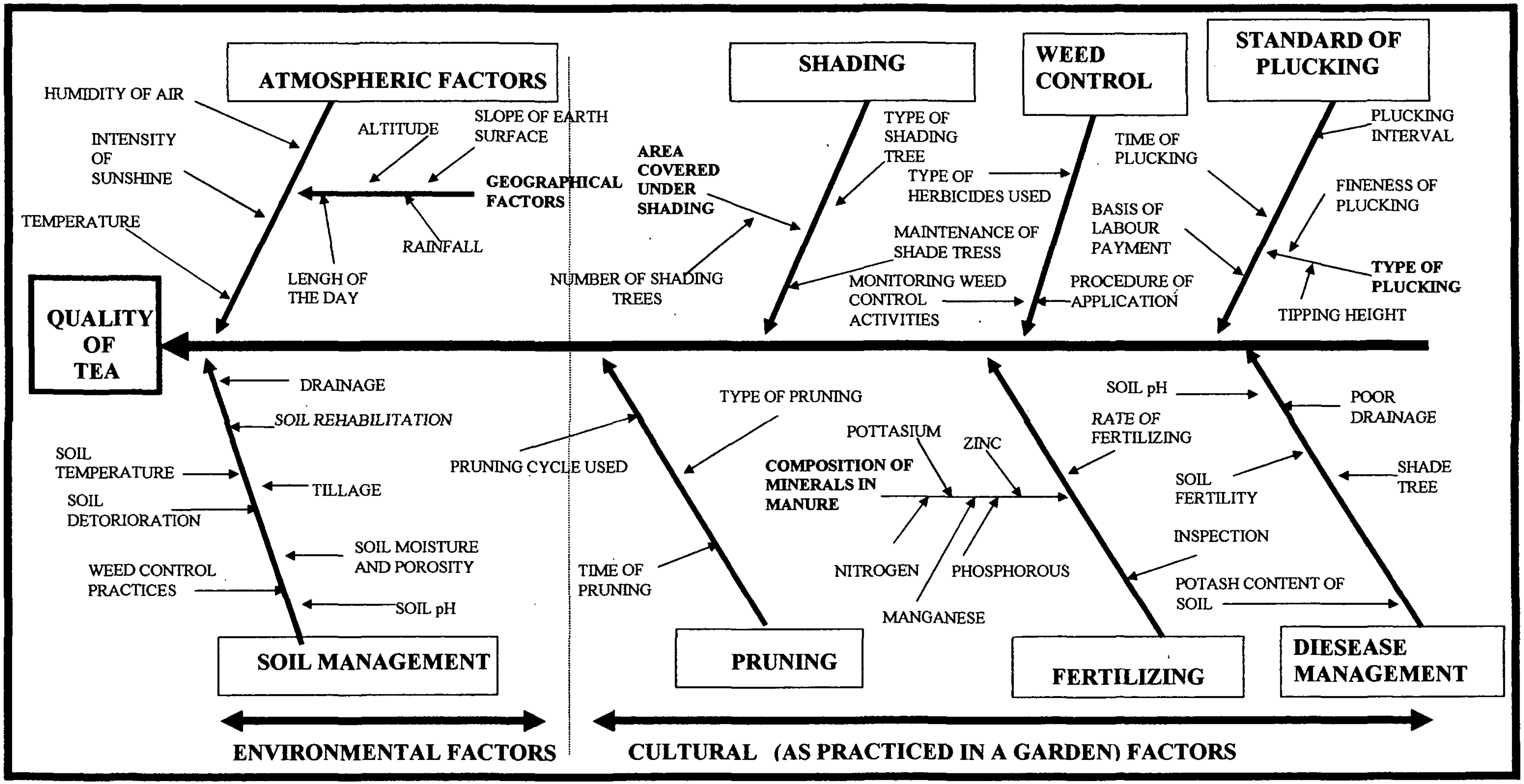


Fig 4.5

Ishikawa Cause and Effect Diagram Showing the Environmental and Cultural Factors Affecting the Quality of Made Tea

4.2.4.1 Treatment During and After Plucking

(i) While plucking, bruising of leaves should be avoided.

(ii) Leaf should be handled with care and packed lightly to remain cool and undamaged as rough handling and tight packing result in damage and heating up of the leaf.

(iii) Contamination with foreign matter, e.g.: sand and soil should be avoided.

(iv) Since pluckers are usually paid on the basis of quantity of leaves plucked, strict inspection is required to avoid all kinds of malpractices such as hiding heavy stones or extra moisture with the purposes of increasing the weight. A paying system based on both quality and quantity of the plucked leaf is desirable.

4.2.4.2 Treatment During Transportation

(i) Plucked leaf should be delivered at the factory as quickly as possible avoiding any damage during transportation

(ii) The containers should be stalked lightly to allow air to pass through.

(iii)After arrival at the factory withering should be started with the least possible delay.

(iv)Leaf awaiting withering should not be stored in sacks or baskets or in heaps.

Despite every precaution, leaf arriving at the factory may reach a temperature up to 32°C depending on ambient temperature. Negligence in packing and transporting of leaf could therefore result in much higher temperatures leading to loss in quality.

The modes of filling the leaf in the container lead to growth of bacteria. Table 4.1 shows the rate of bacteria formation in different modes of filling tea in basket used for carrying tea.

Table 4.1

Number of Bacteria in 1 Gram of Leaf Depending on the Method of Packaging

Mode of filling the basket	Temperature in the Mass of Leaf in Degree Centigrade	Number of Bacteria in 1 Gram of Leaf
Loosely Packed Leaf	26	10000
Compactly Packed Leaf	34	120000

The factors related to leaf treatment affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4.6

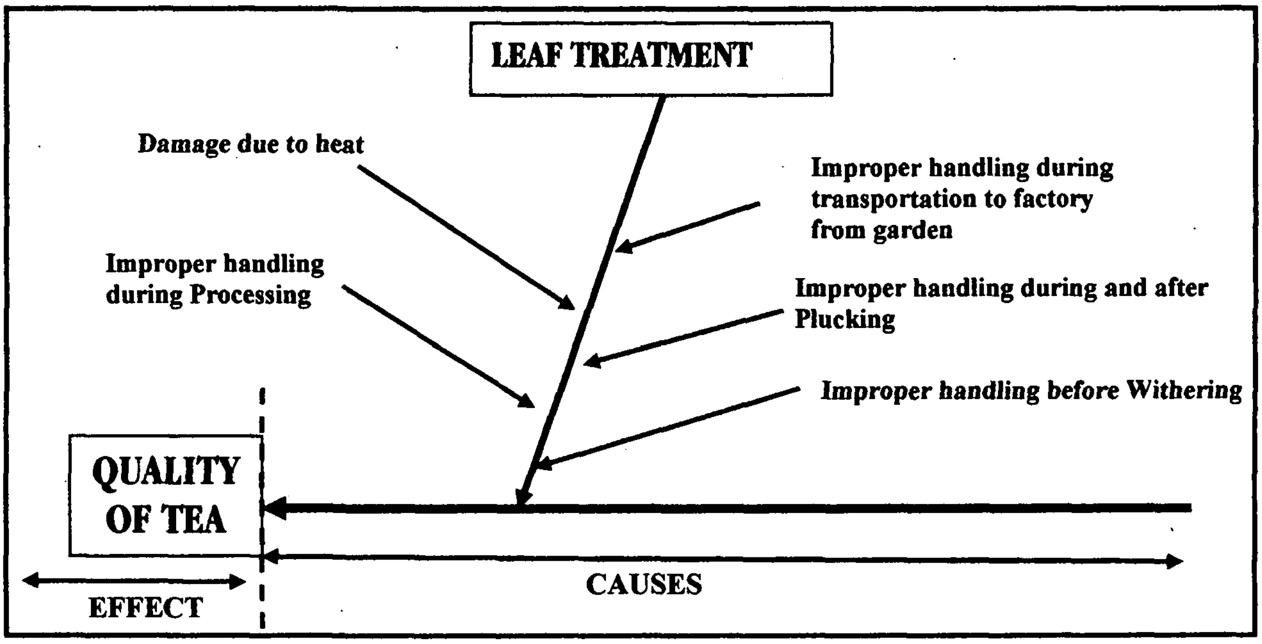


Fig: 4.6
The Leaf Treatment Factors Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4.7

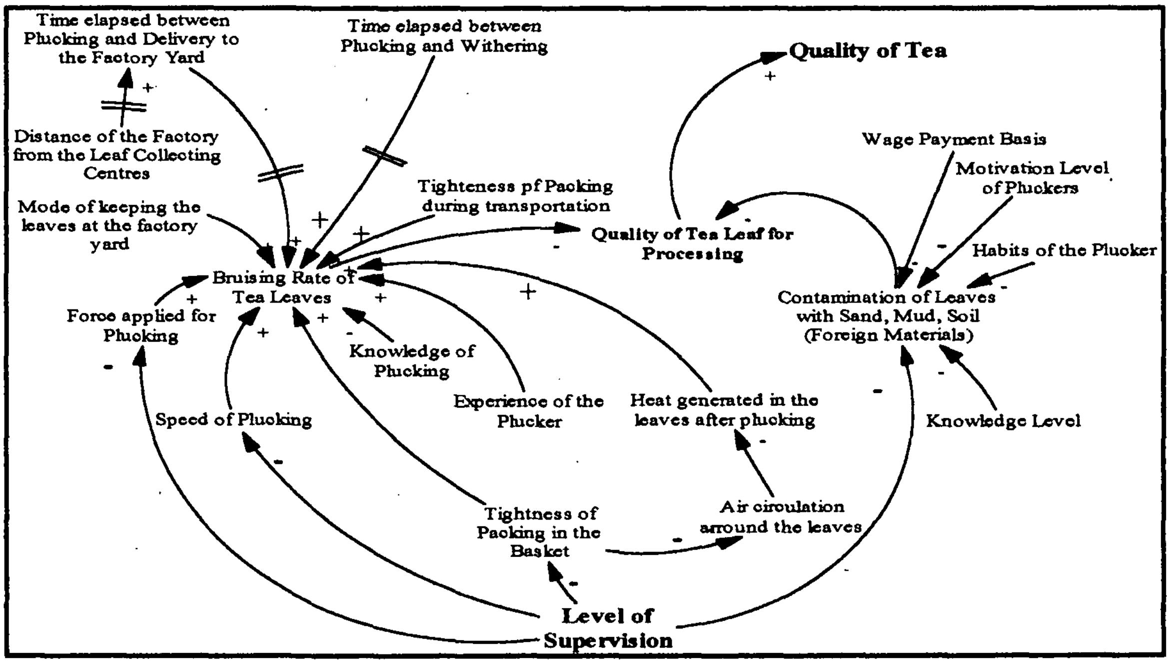


Fig 4.7
Causal Relationship among the Leaf Treatment Factors Affecting Quality of Tea

4.2.5 Factory Hygiene Factors

Tea being within the purview of food and beverage industry it is important to maintain a clean and pollution free condition inside and even immediately outside the factory premise. Moreover, for production of top quality tea, the factory must be airy and clean. Even a slight contamination of bacteria is sufficient to reduce the brightness and briskness of the liquor.

The factors related to Factory Hygiene affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4.8

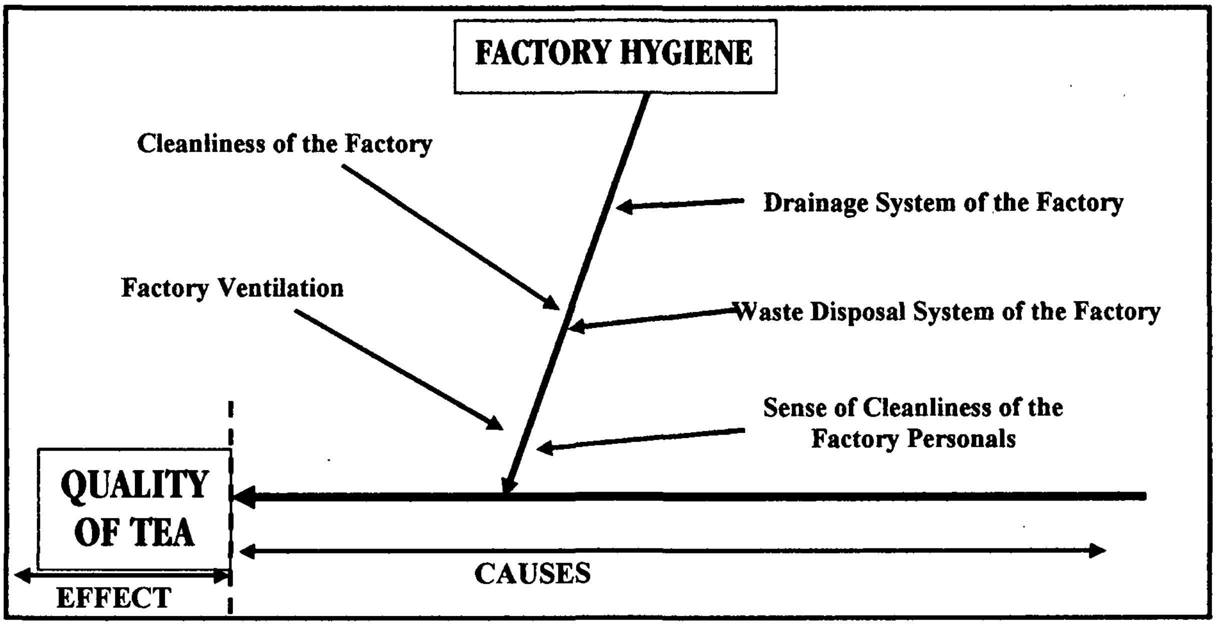


Fig: 4.8
The Factory Hygiene Factor Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4. 9

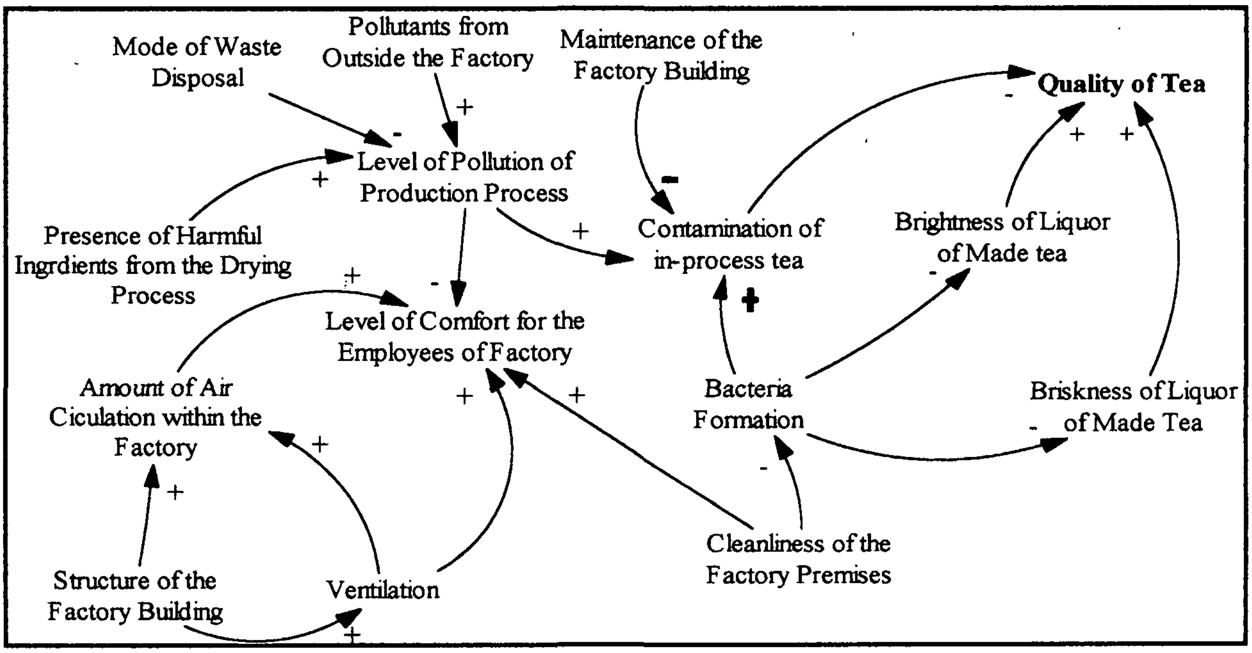


Fig 4.9
Causal Relationship among the Factory Hygiene Factors Affecting Quality of Tea

4.2.6 Maintenance Factors

Maintenance is an important function of the tea estate and is primarily concerned with controlling condition of productive equipment and other capital assets. Maintenance activities in the factory of a tea garden are affected by working conditions. Safety, inspection procedure and the frequency of inspection, quality of safety instructions, the work activities, proper maintenance of the engineering records, the size of maintenance crew, setup of the maintenance staff and devotion of maintenance personnel etc. determine the level of maintenance function in a tea garden.(Ghose,S.; 1999)

The factors related to maintenance affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig.4.10

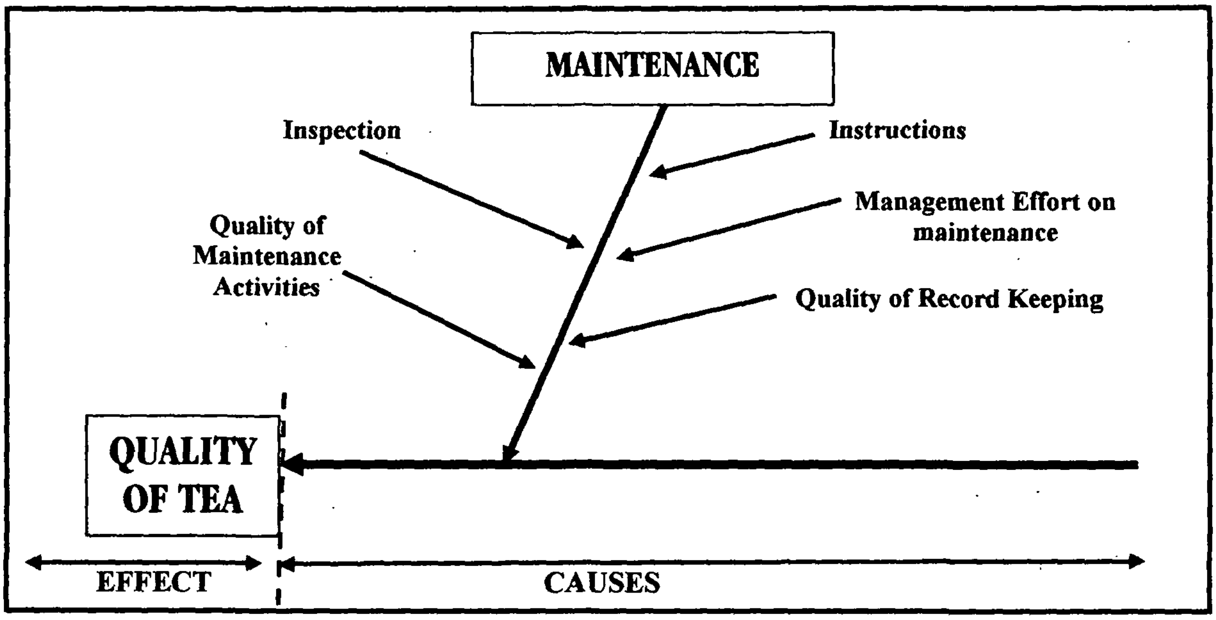


Fig 4.10
The Maintenance Factors Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4. 11

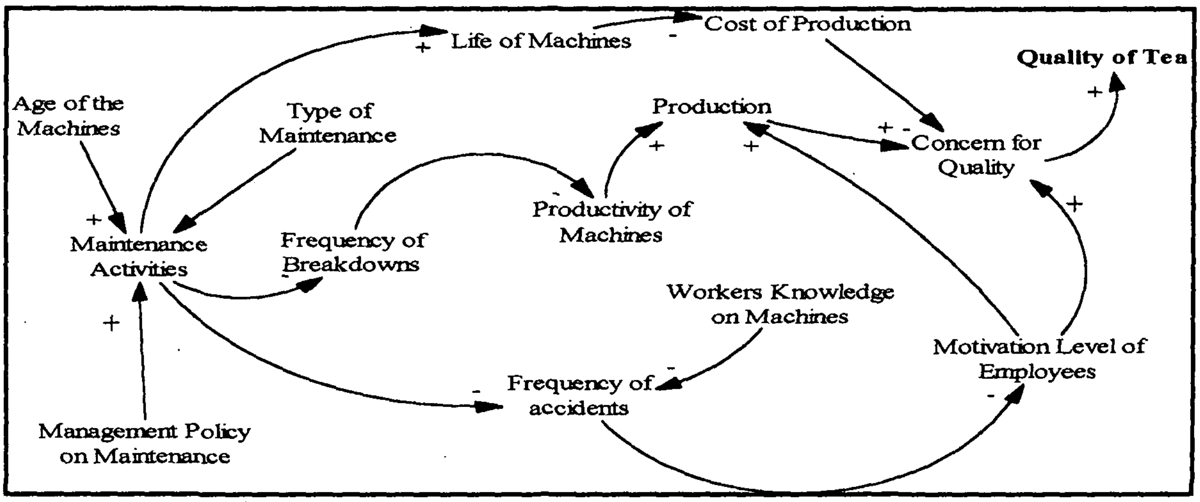


Fig 4.11
Causal Relationship among the Maintenance Factors Affecting Quality of Tea

4.2.7 Labour Factor

Reports from Managers of different tea gardens pointed out that one of the main problems of most of the Tea Gardens is the labour related problem, specially the problem of absenteeism of labourers.

The factor has an indirect effect on tea quality. The various factors which affect the motivation level of labourers are:

1. Promotion strategy of the management
2. The value or volume of work
3. The procedure of discharging workers
4. The duration of work and wages
5. Communication gap with the management
6. Location of the factory
7. Welfare standards adopted by the management
8. The level of education of the labour force

The factors related to labourers affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4. 12

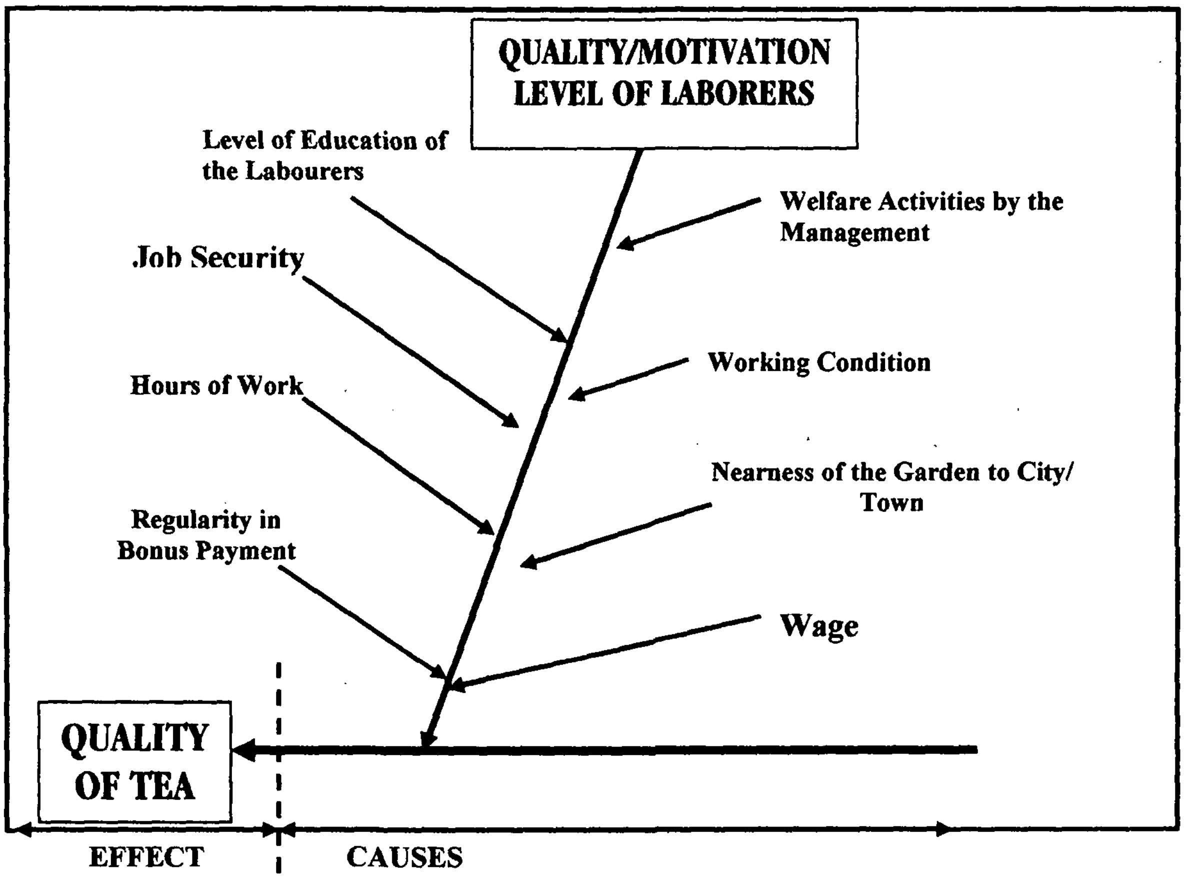


Fig 4.12
The Labour Factor Affecting the Quality of Made Tea

The causal relationships of the various factors are shown in Fig.4.13

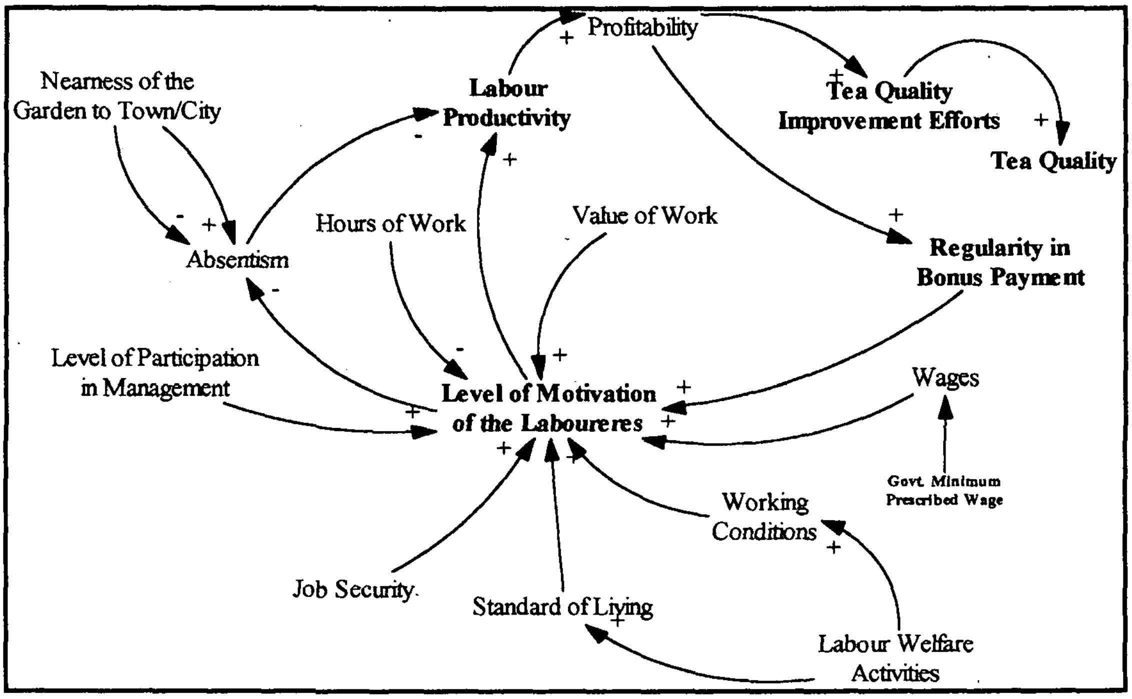


Fig 4.13
Causal Relationship among the Labour Factors Affecting Quality of Tea

4.2.8 Process Factors Affecting Quality of Tea

All the processes involved in the tea processing play an important role in building the quality of tea. It should always be kept in mind that only careful and proper processing will bring out the full potential of the green leaf.

4.2.8.1 Factors of Withering Process Affecting Quality of Tea

The object of withering is to produce from varying batches of leaf a residual material with uniform moisture content. It is used to prepare the leaf for the rolling process by making the leaf tissues flaccid and permeable to juices which the rolling will wring out and spread evenly upon the surface.

The process of withering is normally carried out by spreading thinly on banks of trays or 'tats' made of tightly stretched jute Hessian or wire netting. 2 or 3 sq. meters/ kilograms of fresh leaf are a normal density of spread. The tats are spaced 14 cm apart, to allow free access of air, with alleyways of each bank to allow distribution and removal of leaf.

In Assam, the open or 'chung' type of withering process adopted has no control on rate of withering. In this type, the withering process is controlled by adjusting the thickness of spread and the length of wither is dependent entirely on the prevailing hygrometric conditions of the ambient air. The withering houses are generally detached from the rest of the factory and have no walls. During wet weather conditions the relative humidity of air is decreased by blowing air from outside by means of fans.

4.2.8.1a Bio-chemical changes in withering

After plucking, enzymic activity and soluble amino acid content increase for 20 hours; thereafter the changes are erratic. Caffeine, however, increases throughout the experimental period (72 hours). On the other hand, actual withering is necessary to bring about increasing permeability of cell membranes on which, to a considerable degree, the mingling of enzyme, polyphenols and oxygen depends in orthodox manufacture. Enhanced enzyme efficiency promotes quicker and more efficient fermentation; amino acids are thought to influence colour and aroma. Caffeine is a stimulant that makes tea a desirable beverage. (Khanna, A.I.N.; 1999)

4.2.8.1b Effects of improper withering

Too light wither will overtax the drier in the firing process. Under-withering tends to produce flaky tea of low apparent specific gravity. The red leaf in the dried tea increases if withering is too tight. This reduces the appearance of tea. With long withers there is a risk of the rapid formation of unwanted bacteria which produce dull tea having low quality characteristics.

The factors which affect withering process are thickness of spread, condition of leaf, period of wither, standard of plucking, etc.

4.2.8.1c Type and condition of leaf

The rate of wither is markedly influenced by the type of leaf i.e., clone or 'jat', pruned or unpruned, the size and the general composition of the plucked material etc. Tender leaves diffuse moisture at a faster rate than the mature leaves or the stalks. When the leaf is of a mixed pluck, a considerable variability or unevenness on the wither can be expected

4.2.8.1d Thickness of spread

Depending upon the various factors like type of leaf, size, condition and thickness of leaf spread may vary between 8-20 cm and may be a quite critical factor in determining the quality of the finished product.

4.2.8.1e Period of wither

This is ascertained by taking both physical and chemical wither into consideration. Though physical wither is achievable within 3-4 hrs, chemical wither requires 12-16 hrs for completion and therefore, it is necessary to wither the leaf for a minimum period of 12-16 hrs.

4.2.8.1f Drying capacity of air

The drying capacity of air used for withering is determined by factors like hygrometric difference, temperature, volume of air and its movement and pressure exerted by air. When there is surface moisture in the leaf, the humidity potential of air surrounding the leaf controls the evaporation. Humidity potential of air is an inverse function of the humidity of air. Higher the humidity lower is the humidity potential and vice-versa. The humidity potential of highly humid air can be increased by raising the temperature by external means.

The temperature of leaf withering is an important parameter. There are harmful effects of withering at higher temperature. The surface temperature of a wet leaf usually comes closer to wet bulb temperature of air. But as soon as the surface becomes dry, the temperature rises to dry bulb temperature of the air. Therefore, while using hot air, one should use lower dry bulb temperature. Supply of hot air at 32°C (90°F) and with a hygrometric difference of 6°C (11°F) has been found to be useful in giving a good wither and yielding good quality tea. Moreover, during withering hot air should be used only during the earlier part and not afterwards.

It may be noted that theoretically the amount of energy in the form of latent heat required to evaporate 1kg of water is same both for withering and drying. Since the process of withering is carried out at lower temperature, volume of air required for withering is very high. But too high a flow is likely to produce leaf with uneven wither. On the other hand restrictions of the fan inlet area can result in reduced flow rates and affect the withering process adversely. Table 4.2 shows the effects of under-wither, over-wither and correct wither of tea leaves on processing.

Table 4.2
Effect of Under-wither, Over-wither and Correct- wither During Processing

Effects on	Under Wither	Over Wither	Correct Wither
Appearance	Open and flaky	Well twisted	Well twisted
Rolling	Considerable expression of juice during rolling involving loss of solids responsible for liquor characteristics	Hard pressure must be employed involving possible loss of tips	Little expression of Juice
Tips	Loss of tips during rolling and pale colour of tips in made tea	Silvery tip due to insufficient juice deposit on the hair of bud	Golden appearance of tip
Possibility of bacterial infection	Very high	Under control	Under control
Stewing	Possibilities exist during drying	Unlikely	Possibilities minimized
Liquor	Inferior in every respect with a possible brassy taste	Considerable loss in colour and strength	Normal liquor characteristics

The causal relationships of the withering process factors are shown in Fig.4.14

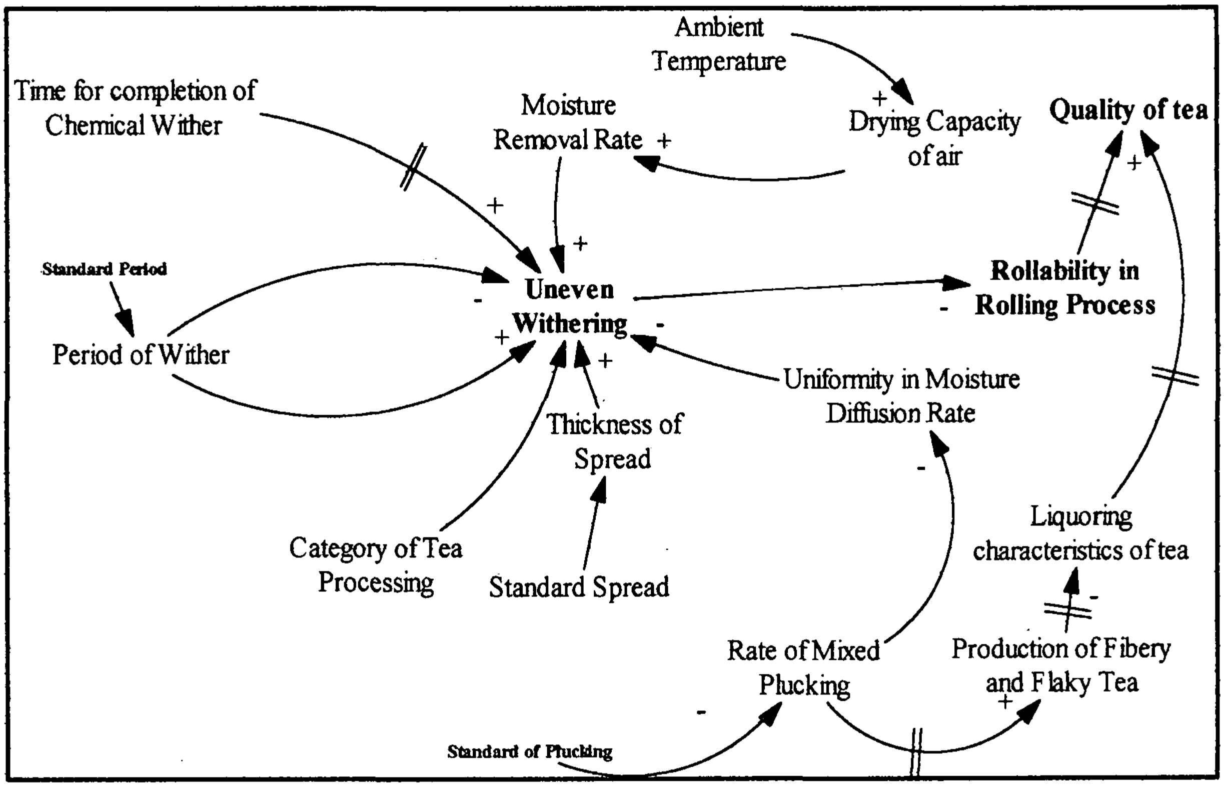


Fig 4.14
Factors of Withering Process Affecting Quality of Tea

4.2.8.2 Factors of Rolling Process Affecting Quality of Tea

When a satisfactory wither has been obtained the leaf is ready for rolling, which twists the leaf, breaks it up and expresses the juices. The rolling process is intended to initiate fermentation and find a balance between appearance and liquor. The object of rolling withered leaf is two folds:

- To rupture the leaf cells and release enzymes, and
- To give a curl or twist to the leaf.

Rolling initiates the process of fermentation. In green leaf catechins and enzymes remain apart; when leaf cells are ruptured these come together and in the presence of atmospheric oxygen, form into Theaflavins (TE) and Thearubigins (TR). (Das, et al.,1999)

The rolling process demands due care in deciding the number of rolls required and the period of rolling. The rolling process factors contributing to tea quality are:

- Condition of leaf after withering
- Roller charge and speed.
- Pressure applied on leaf in Rolling Process
- The rolling temperature.
- The type of tea required

Factors that prevent excessive heat generation during rolling and in consequent loss of quality and flavour are:-

- Good leaf circulation.
- Raising the pressure caps of rollers at intervals.
- Reduced charge particularly for later rollers under high pressure
- The use of cold humid air in the rolling room.
- Reduced rolling period and light wither.

The causal relationships of the fermentation process factors are shown in Fig.4.15

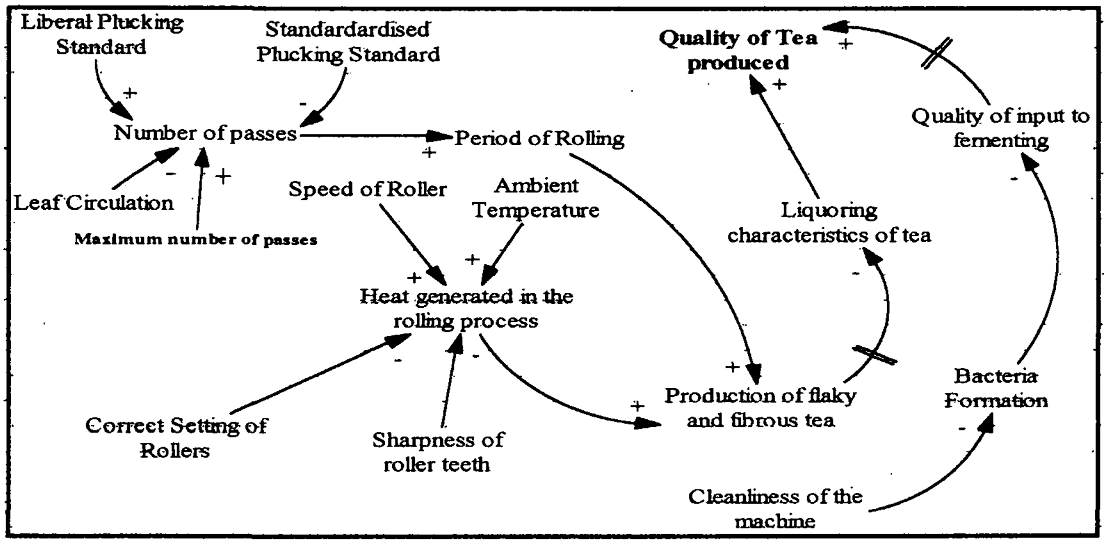


Fig 4.15
Causal Relationship among the Rolling Factors Affecting Quality of Tea

4.2.8.3 Factors of Fermentation Process Affecting Quality of Tea

Fermentation process is considered to be one of the most important processes in Black Tea processing as most of the desirable properties of tea are produced during this process. The most important characteristic components of tea leaf are polyphenols in the cell sap. During fermentation, some of the polyphenols are converted to compounds which are mainly responsible for liquoring qualities of a cup of tea. (Goswami, et al.,1999)

The process of Fermentation is mainly affected by the rate and period of fermentation and the fermenting temperature (Dhan. I. K.; 1995). However, all the important characters of tea are not developed at the same rate. Briskness, Strength and Colour (with milk) changes with time and temperature. Each character is at its best at different times. It may happen that where, as a rapid fermentation at a high temperature suits a certain tea, a longer fermentation at a lower temperature might prove more suitable for others. The most suitable temperature under given condition will depend on the characters the made tea is required to have. By shortening or lengthening the period of fermentation, the degree of colour and quality can be varied to suit different requirements.

The other factors, which affect the tea quality, are as follows: -

- Leaf characters
- Density of spread
- Fermenting condition
- The degree of leaf distortion during rolling etc.

The factors of this process contributing to quality of made tea are discussed below:

4.2.8.3a Period of fermentation

During fermentation the colour of the processed leaf changes from green to coppery-red and the liquor characteristics develop. The important liquor characteristics are briskness, flavour, colour and strength (Dhar. T.K.; 1999). The effect of fermentation period on tea quality is shown in the fig 4.16

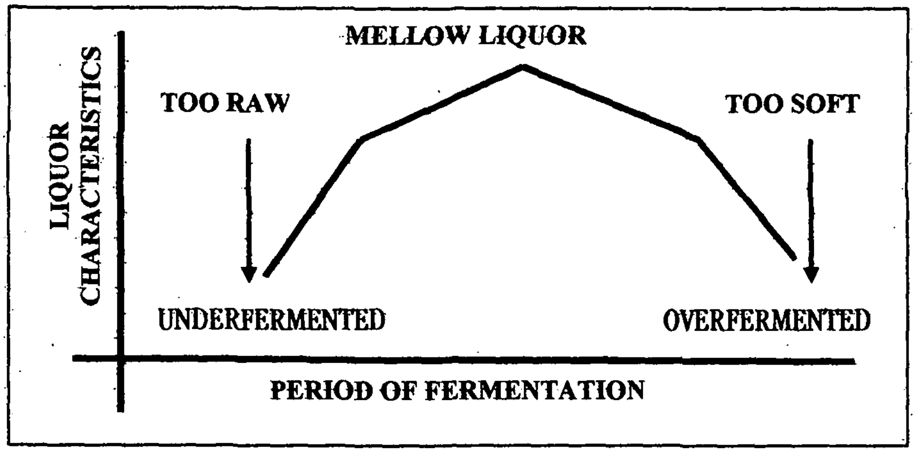


Fig. 4.16
Effect of Fermentation Period on Tea Quality

The reaction during the fermentation process and variations in the development of characters are shown in the figure 4.17

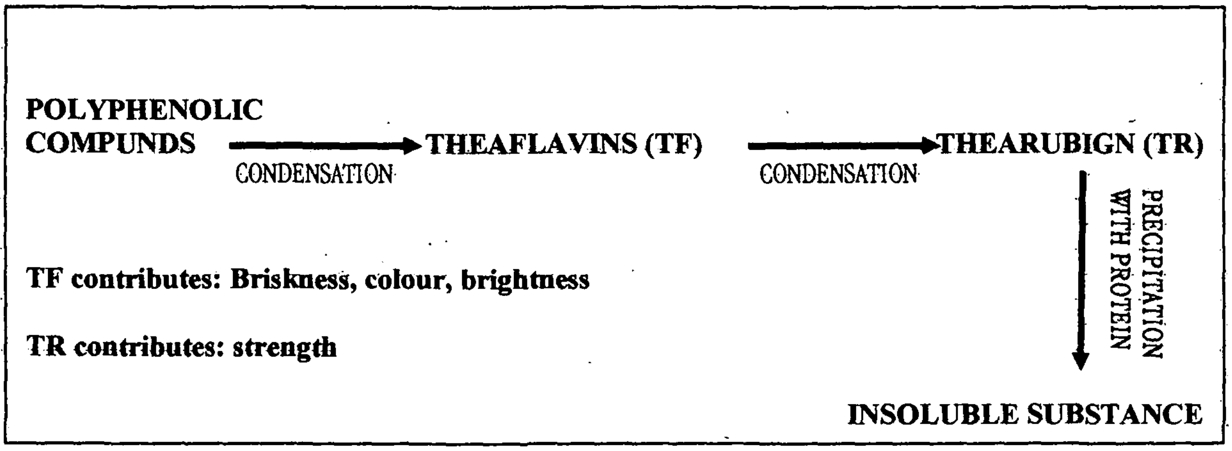


Fig. 4.17
Reaction During Fermentation Process

It is apparent that no two liquor characters are at their optimum at the same time. When the strength is at its best, the briskness has already fallen off. Depending on the severity of the treatment and the type of leaf, the length of fermentation should be a compromise among all the liquor-characters. As it has been explained above, more severe the cut, the less is the fermentation time required. Thus CTC manufacture requires lesser fermentation time than the orthodox. (Dhan.,I.K., 1995)

4.2.8.3b Fermenting condition

Temperature has a profound effect on the process. At lower temperature more TF is formed. TFs are related to the brightness of the liquor (infusion) and TRs to its depth (body and strength) ideal fermentation produces a proper balance of TFs and TRs

It has already been stated that the room temperature should not exceed 29°C (85°F) during fermentation. In North East India the temperature invariably is higher in the afternoon and the air humidity is low. This results in the leaf surface becoming dry and black. The fermenting room should have provision for humidified air to keep the room cool and fresh. The temperature should be maintained at 29°C $\pm$ 1°C with a hygrometric difference of 1.5°C (2°F) (Ravindranath, S.D.,1999). Adequate ventilation is to be provided to effect regular air changes.

The initial oxidation of polyphenols is greatly influenced by temperature. The enzymic oxidation proceeds most rapidly at about 29°C (85°F), and above and below this temperature the activity is dropped. Most of the enzymes are destroyed at about 54°C (130° F). The changes from the oxidised polyphenols to various TFs and TRs are chemical and, therefore, increase at higher temperature. Since both enzymic and chemical oxidations proceeds at different rates at different temperatures, it is difficult to decide the optimum fermentation time.

Fermentation is more active between 27- 29°C (80-85°F) and completely stops between 54 - 65°C. It is therefore desirable that at the green leaf processing stage the temperature is maintained at around 29°C (85°F).

4.2.8.3c Assessment of fermentation

Fermentation is currently assessed in the factory by visual inspection and "Nose" test. While one may be quite lucky in lifting the leaf at the right fermentation time, however, on most occasions the leaf is picked up after it has been over fermented.

4.2.8.3d Degree of wither

Characters of both the withered and the rolled leaf affect fermentation. An uneven withering usually results in uneven fermentation. Fermentation can be at its best when the leaf has the right physical condition and the cells are permeable which allow oxygen to diffuse more quickly into the leaf. In unwithered leaf the juice is usually expelled during rolling. The juice contains soluble components and their loss will result in poorer quality tea. It is, therefore, desirable that only as little juice should be expressed as is necessary for proper mixing with the rolled leaf.

4.2.8.3e Rolling

During rolling, the tender leaf parts are bruised first, and then only the hardened leaf parts are disintegrated. Thus the fermenting requirements of the fine particles will be different from those of the coarse particles. The coarse particles, however, can be fermented as well as fine leaf at the same rate if the same number of cells are disintegrated by applying adequate pressure. The rupturing of cells in the coarse leaves thus requires longer rolling time. The various fractions of leaf produced by the repetitive rolling are fermented separately for different periods. Tightly twisted leaf, as produced in orthodox manufacture, is difficult to be penetrated by air, and as such it takes longer fermentation time. Similarly, severe distortions during CTC manufacture help in quicker fermentation because of easier oxygen penetration.

The causal relationships of the fermentation process factors are shown in Fig.4.18

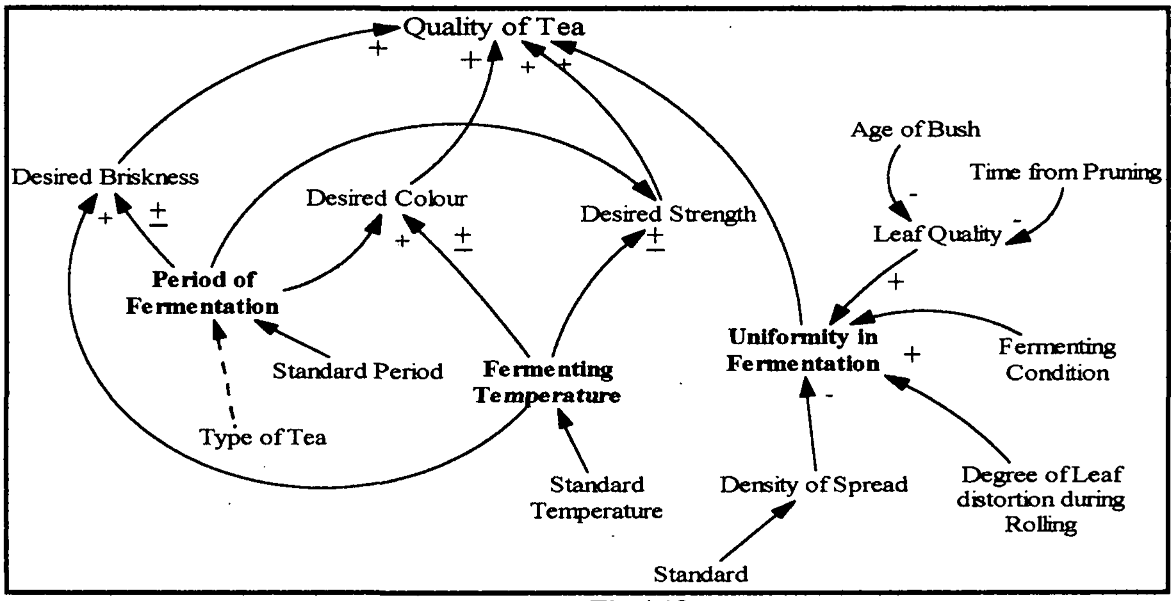


Fig 4.18
Causal Relationship among the Fermentation Factors Affecting Quality of Tea

4.2.8.4 Factors of Drying Process Affecting the Quality of Tea

The objectives in drying (commonly called firing) are:

- to arrest the fermentation and to fix the desirable properties.
- to obtain a finished product that is stable and can be handled and transported

When a mass of macerated leaves has attained the required stage of fermentation, it is fired, or exposed to hot air. The objective is to arrest further fermentation by killing all enzymes, as well as render the tea leaves almost totally dry. Since the moisture content of fermented leaves is around 60-66%, for every 3kg of fermented leaves subjected to firing, approximately 1kg of dry tea will be manufactured.

4.2.8.4a Air temperature

Drying of tea, unlike other solids, involves two aspects viz. physical and chemical as mentioned earlier. Therefore, the temperature at which the tea is fired has to be judiciously examined for its suitability. Too high temperature at the initial stage may result in case hardening and blistering. But even if these effects are avoided, a faster rate of evaporation at the initial stage of drying may impart the tea an undesirable harshness due to relatively higher proportion of un-oxidized or partially oxidized matter present in the finished product. On the other hand, too low a drying temperature will slow down the rate of drying and at undesirable high temperature fermentation will be allowed to proceed for a much longer period. This will form a product which will be dull and soft and which may ultimately result in 'Stewing'. In practice an inlet temperature between 82° to 99° C (180° - 210° F) has been found to be satisfactory, keeping in view the economy and efficiency of the drying operation and the liquoring properties of the resulting tea.

Exhaust temperatures, like the inlet temperature, are also important as they indicate the amount of heat extracted from the air stream to dry the leaf. For the existing dryers an exhaust temperature of 49°-54° C (120°-130°F) is advocated. At this temperature, the stewing inside the dryer is minimized and the fermentation of leaf particles in the top tray is brought nearly to a stop.

4.2.8.4b Volume of air

The volume of air required for drying is largely dependent on two factors:

- moisture to be removed
- the drying temperature

The difference between the inlet and the true exhaust temperatures during the first fire is roughly proportional to the amount of moisture evaporated per hour. Other things being equal, any increase in the inlet temperature is usually accompanied by a corresponding increase in the exhaust temperature. Changing of air flow is the easiest method of adjusting the drying condition. If the volume is below normal requirements, the temperature will have to be increased to produce the same amount of heat. The capacity of dryer, however, can be increased by the air volume. Insufficient air flow in a dryer may be due to lower fan speed, small exhaust duct or due to partially closed fan valve. On the other hand, there is a limitation in increasing the air flow as too strong a blast will cause small pieces of leaf to be blown away from the dryer. The fan valve prevents excessive blow out. The drying air is most efficiently used in passing through the bed of leaf instead of just throwing the leaf off the tray because of too high velocity.

4.2.8.4c Thickness of spread

The spread of leaf in the dryer should be of reasonable depth to prevent the air from escaping freely through it. This can be best judged by the movement of the leaf particles in the air flow. Load and velocity of air should be such that the leaf in the upper tray is hardly disturbed, but on the lower trays it should bounce slightly. If no disturbance is observed in the lower trays, the leaf has been spread too thickly, or the air flow is insufficient. Overloading the dryer requires higher drying temperature and a longer drying period. It also sets up a back pressure baffling the air flow and gives uneven drying with loss in quality and irregular infused leaf. In general, a finer material should be spread thinner. Big bulk requires a slightly longer period of drying than fines and should be spread thicker. Spread thickness also depends on the degree of wither. Firing should never be attempted with a set spreader position. A dryer cannot be expected to adjust itself automatically to suit different types of leaves and variation in wither.

4.2.8.4d Period of drying

The time required to dry tea varies with temperature, thickness of spread and volume of air. It is apparent that the two main objectives of drying i.e., desired moisture content in the final made tea (which is normally 3%), and the optimal arrest of fermentation can be achieved even in shorter residence time by increasing the drying rate. It does not, however, necessarily mean that the evaporation rate is also high in such a case. A fast drying rate carries the danger of case-hardening of product. Longer period of drying on the other hand means higher spread thickness which will produce uneven tea due to unevenness in contact between particles and air supply.

Thus, the drying process is affected by the drying time, temperature of air, volume of air and the amount of leaf in each tray. These tea drying parameters should be adjusted in such a manner that good quality tea is produced. The causal relationships of the various factors are shown in Fig.4.19

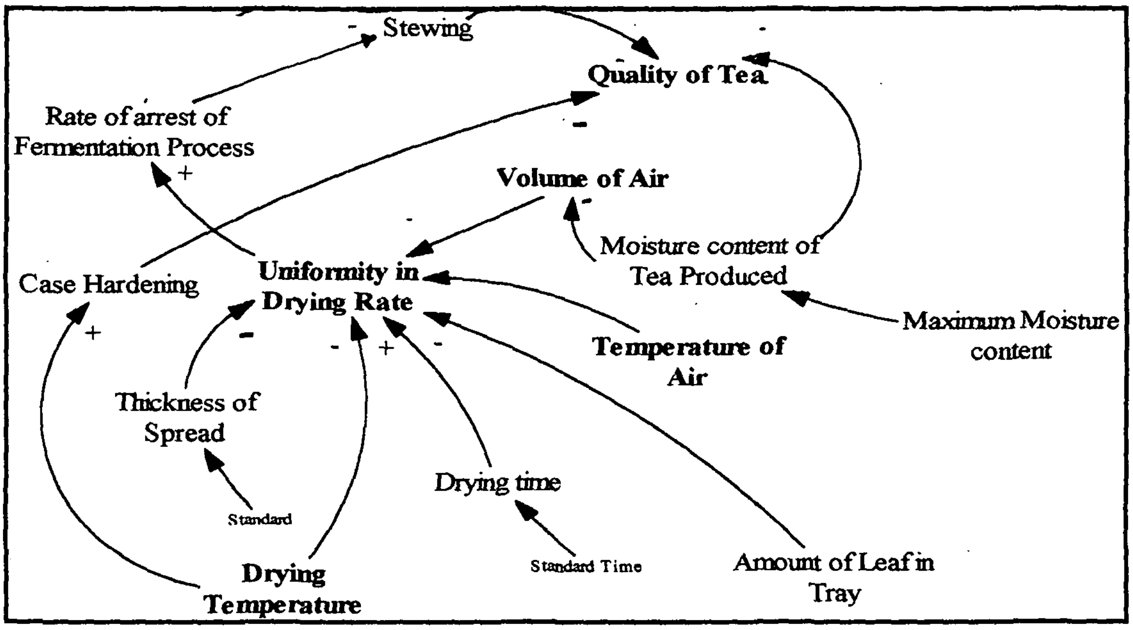


Fig 4.19
Causal Relationship among the Drying Process Factors Affecting Quality of Tea

4.2.8.5 Packaging and Sorting Factors Affecting Quality of Tea

After delivery from drier, the tea is spread out to cool and then temporarily stored to await sorting. Grading is carried out for the most part on mechanically oscillated sieves. These are fitted with the meshes of appropriate size. In some machines the sieves are in banks of diminishing mesh size such that the outfall of the upper member falls on the lower.

For various reasons, often it is not desirable to divide the tea into the greatest possible number of grades. The percentage of leaf suitable for the production of some of the grades is small and it may take too long to collect sufficient quantity of such leaf to make a large invoice to attract attention on the market. Tea grading percentage must, of course, vary according to plucking standards and the market demand. Grading of tea should be strictly of constant standard. The success of this product depends on whether the merit of tea is sufficient to attract particular attentions or not. (Punshi, R.C., 1997)

Normally the grades of tea produced by different gardens differ in quantity. Some estates may find it lucrative to make a particular grade while other estates may produce that particular grade in lesser quantity. The question as to which procedure gives the best return is a vexed one. Variations in grading ultimately cause a price variation in the market. Thus a fresh change in grading may be required for a garden to take advantage of the changed demand in the market.

After the tea has been sorted into respective grades, it is necessary to pack these in suitable containers to ensure that the keeping quality does not deteriorate in transit. All the efforts to prevent tea absorbing too much moisture will go in vein if due care is not taken in packing. Apart from tea chests having to meet certain standards, lining should be moisture-proof and free from foreign taint.

The present mode of packing is not absolutely air-tight and as a result tea does pick up more than 1.5% moisture by the time they reach the UK market. Tea packed in the garden with about 3% moisture may contain about 4-5% moisture, if not more, by the time it reaches UK. It has been found that absorption of this much amount of moisture by the tea before it is consumed has no harmful effect on the liquor characters of tea. In fact, despite this absorption of moisture, due to some chemical changes, the tea acquires mellowness which is a desirable character. It has been found that plywood tea chests with lining of alumina and tissue paper, metalized polyester or cellophane are suitable for packing tea.

Due to scarcity of plywood now-a-days, Tocklai Tea Research Association (TRA) has found an alternative material for bulk packing of tea. The sacks are made from Extensible Kraft Paper, comprising 5 layers of paper to hold about 50 kg of tea per sack. It is 120 cm long x 73 cm wide x 18 cm high.

4.2.8.5a Moisture content

The quality of tea tends to deteriorate at higher moisture content (over 6%) and higher temperature. So tea should preferably be dried to moisture content of 3%, be packed at 4 to 5% and further protected from excessive uptake.

4.2.8.5b Inspection

The sorted tea should be inspected for its different physical attributes. Tests are needed to ensure the absence of health hazardous substance like insecticides, pesticides etc.

4.2.8.5c Quality of packaging

The quality of packaging proves to be an important factor in the market for sales. Dull packaging fails to attract customers. Material for packaging decides the ex-factory quality of tea. Air tight packaging only ensures good quality at the customer's end.

4.2.8.5d Time between sorting and packaging

The moisture content of the final tea increases considerably with the increase of time between sorting and packaging. The Causal relationships of sorting and packaging process factors are shown in Fig.4.20

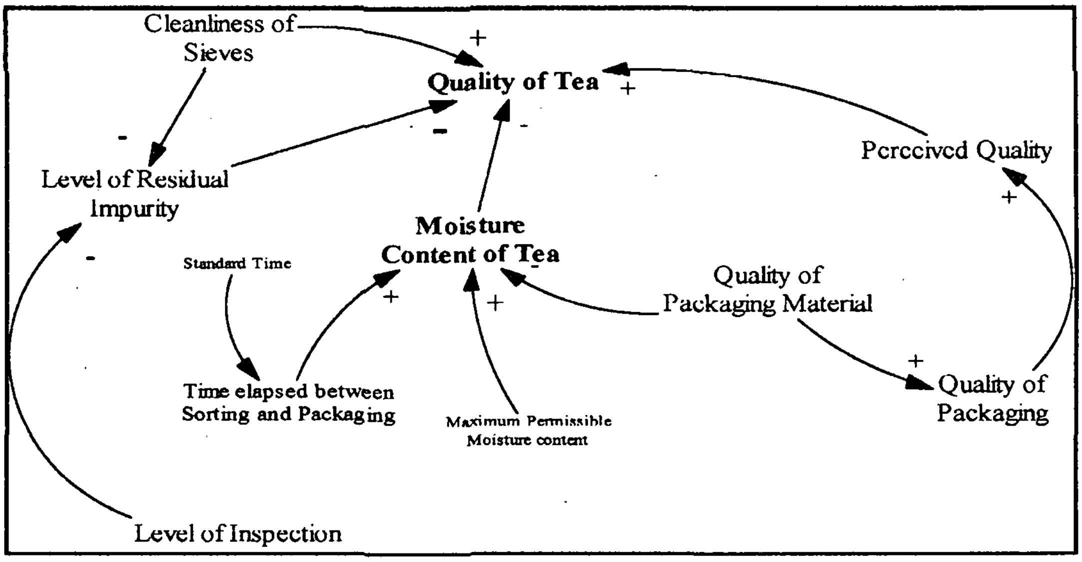


Fig 4.20
Causal Relationship among the Sorting and Packaging Process Factors Affecting Quality of Tea

The Ishikawa Cause and Effect diagram of all the process factors determining quality of made tea is shown in Fig 4.21.

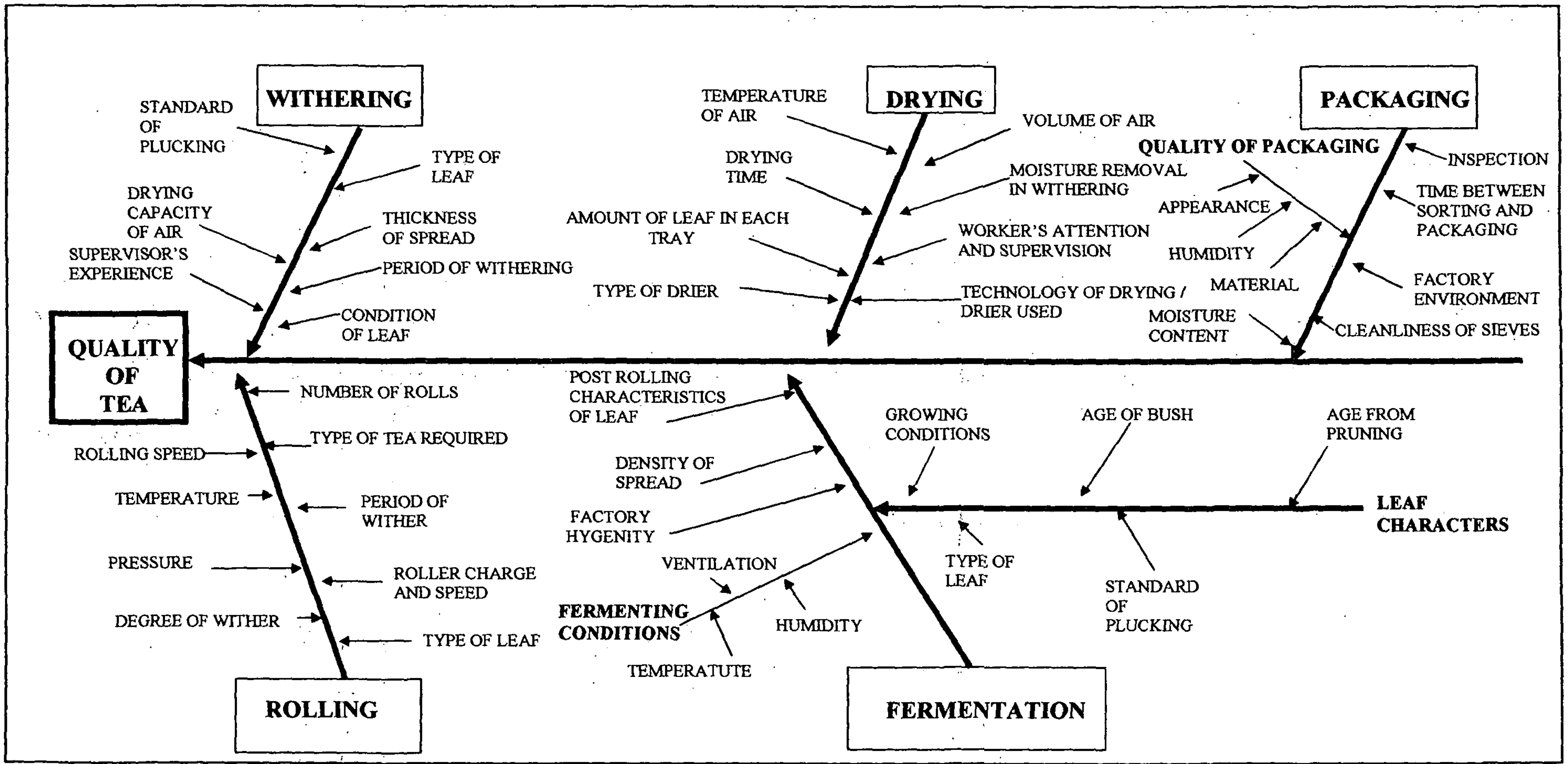


Fig. 4.21:

Ishikawa Cause and Effect Diagram Showing the Processing Factors Affecting the Quality Made Tea

4.3 CONCLUSION

The model, 'Factors Affecting Quality of Tea', classifies the factors into two major heads 'Management Controllable Factors' and 'Uncontrollable Factors'. The classification of factors under both the categories are shown in the Table 4.3

Table 4.3
Classification of Factors Affecting Quality of Tea

MANAGEMENT CONTROLLABLE FACTORS	MANAGEMENT UNCONTROLLABLE FACTORS
LEAF TREATMENT FACTORS	ENVIRONMENTAL CONDITIONS
CULTURAL FACTORS	
MAINTENANCE FACTORS	
PROCESSING FACTORS	GENETIC FACTORS
CULTURAL FACTORS	
FACTORY HYGIENE	
LABOUR	

In the subsequent chapters (Chapter VI and VII) of this thesis an attempt has been made to:

- assess the level of awareness of these controllable factors among the people of Tea Industry in the light of TQM philosophy.
- develop an assessment tool which is expected to help the management to identify the problem areas where much stress is needed for improvement in quality culture of the garden.

CHAPTER – V

An Experimental Study on Energy Consumption in Tea Processing

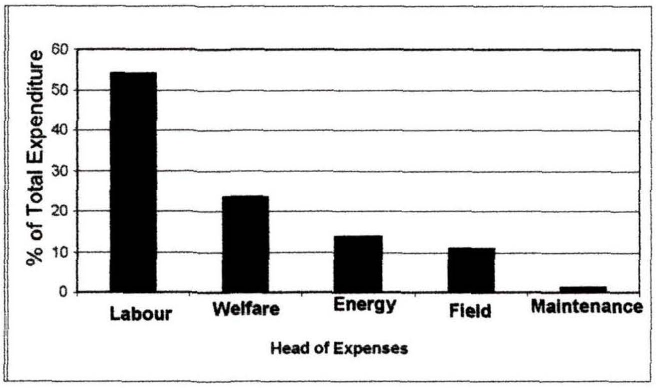
5.1 Control of Expenditures

TQM philosophy demands continuous improvement of the system by identifying and eliminating unnecessary costs. In order to assess the unnecessary costs involved in tea processing, a PARETO analysis on expenditures incurred at the garden level was carried out. During the visits to different tea estates, it was felt that expenditure control has been an issue of serious concern for the tea industry for some time now. In recent times, the changing economic scenario, the rising costs of production and uncertainty in price realization have brought this issue under brighter focus.

The need of the hour is to identify a practical and cohesive strategy for evolving a solution to eliminate unnecessary costs and thereby improving performance of Tea Estates. As revealed by the Managerial level people, wastage in all areas of tea plantation and production is a major aspect to be stressed a lot.

5.2 PARETO Analysis of Expenditures of a Tea Garden

In order to find out the most potential areas of cost reduction in a tea garden, a PARETO Analysis has been done on the various heads of expenditures of a garden. The data used in this analysis have been retrieved from the Questionnaire as given in Appendix IB. The pattern of expenditure in different heads are shown in the Fig 5.1



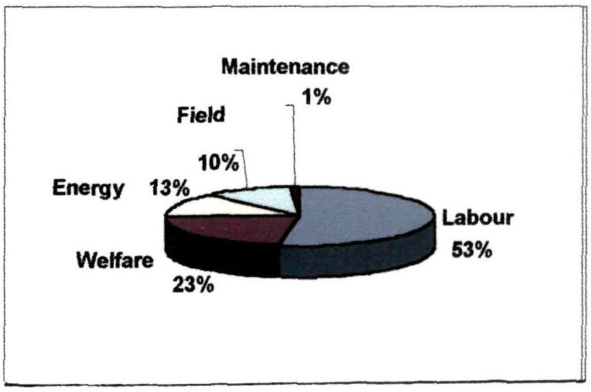


Fig. 5.1
Distribution of Expenditures of a Garden

From the PARETO analysis it has been seen that the following combinations of expenditure categories contribute most to the total expenditure.

- Labour + Welfare = 76%
- Labour + Welfare + Energy = 89%

In case of tea gardens of Assam, though major expenditures are incurred on labour and welfare activities, but to a great extent the labour and welfare expenditures are mainly statutory in nature. (Refer Appendix - IVC).

Therefore, Energy sector is considered for the purpose of analysis in terms of wastes. In this Chapter, an attempt has been made to pinpoint the potential areas of tea processing for cost reduction in terms of reduction in energy consumption.

5.3. Energy Consumption in Tea Processing – An Experimental Study

A number of studies have been made till date on the aspect of energy consumption in tea processing (Desilva (1994) and (Das 1997)). The author conducted an experimental study to analyze the Energy Consumption Pattern (both Electrical and Thermal) at various stages of CTC Tea manufacturing in a Garden located in the Jorhat District of Assam having its existence for more than 100 years. The production machineries (CTC machines, Rotorvanes, other auxiliary equipments) in this garden are considerably old. The factory uses two types of dryers: the Endless Chain Pressure (ECP) dryer is quite old and the Quality Dryers are relatively new. The experiment was conducted over two days.

5.3.1 Specifications of Various Processes in the Unit under Study

1. Specifications of the Withering Unit:

Number of troughs	:	42
Size of troughs	:	72 ft x 6 ft
Capacity of trough	:	864 – 1080 Kg/trough
Type of trough	:	Wire net type
Thickness of spread	:	30 cm
Fan size	:	39 inch diameter

2. Specifications of the CTC Machines/Rotorvanes

Number of CTC Machines	:	2
Teeth per inch (TPI)	:	8 in the 1st cut
		10 in the 2nd cut
		8 in the 3rd cut

Capacity : 800 Kg/hour

Teeth Angle : 45 degree in the 1st cut

65 degree in the 2nd cut

70 degree in the 3rd cut

Number of rotorvanes : 2

3. Standards followed in Fermentation are given in Table 5.1

Table 5.1
Standards Followed in Fermentation

Temperature	Fermenting time	
	CTC	**Orthodox**
71^0 F – 75^0 F	1 hour 30 minutes	3 hours 20 minutes
76^0 F – 80^0 F	1 hour 25 minutes	3 hours 00 minutes
81^0 F – 85^0 F	1 hour 20 minutes	2 hours 45 minutes
86^0 F – 90^0 F	1 hour 15 minutes	2 hours 20 minutes

4. Drying Process:

a. Types of Dryer:

i) ECP Dryer: 1 (ii) Quality Dryer: 3

b. Fuels used:

Generally T.D. oil and coal are used for drying of tea particles. Out of four numbers of dryers in the estate factory, coal is used in the ECP dryer and T.D. oil is used in the three Quality dryers.

Specifications of Electrical Motor/Equipments used for different processes are given in Table 5.2

Table 5.2
Specifications of Electrical Motor/Equipments Used for Different Processes in the Garden Selected for Study of Energy Consumption

Sl. No.	Process/ Description	Number	Rated Output			Efficiency (%)
			HP	N (rpm)	KW	
1.	Withering					
	a) Trough Motor	30	3	935	2.2	79
	b) Hot Air Blower Motor	1	7.5	1440	5.5	84
	c) Hot Air Fan Motor	1	20	1455	15	87
2.	CTC					
	a) **Tea Master**					
	i) Rotorvane	1	20	1460	15	87
	ii) CTC 1st Set	1	25	1445	18.5	88
	iii) CTC 2nd Set	1	20	1455	15	87
	iv) CTC 3rd Set	1	20	1455	15	87
	b) **Steelsworth**					
	i) Rotorvane	1	15	970	11	86
	ii) CTC 1st Set	1	20	970	15	87
	iii) CTC 2nd Set	1	20	955	15	87
	iv) CTC 3rd Set	1	15	955	11	85.5
3.	Fermentation					
	Humidification Plant					
	i)Pump Motor	1	3	1440	2.2	79
	ii) Fan Motor	1	15	1440	11	87
4.	Drying					
	a) Quality Dryer i) Hot Air Fan Motor	1	30	1430	22	88.5
	ii) Spreader Motor	1	2	1440	1.5	79
	iii) Output Motor	1	5	1440	3.7	82.5
	iv) Heater of TD Oil	1			10	
	b) ECP Dryer i) Blower Motor	1	2	1420	1.5	79
	ii) Hot Air Fan Motor	1	20	1440	15	87.6
5.	Sorting and Grading					
	a) Vibro Motor	6	2	1405	1.5	79
	b) Vibro Conveyor Motor	1	1.5	1070	1.1	77.5
	c) Vibro Conveyor Motor	1	0.75	1070	0.55	62

5.3.2 Calculation of Electrical Energy Consumption

The experiment was carried out over two days. The data obtained and the calculations of electrical energy consumption are given in Table 5.3 and Table 5.4 respectively.

Table 5.3
Day 1: Electrical Energy Consumption

Green Leaf = 23960 Kg					Dry Mouth = 5461 Kg	
Sl. No	**Process**	**Duration (Hrs:Min)**	**Motor Power Consumption x No. of Motors**	**Efficiency**	**Energy Consumed (KWH)**	**Energy Consumed Per Kg of Made Tea (KWH/Kg)**
1	**Withering**					**1002.53/5461 = 0.18**
	Trough Motor	12:00	2.2 x 30	79	**1002.53**	
2.	**CTC**					**0.279**
	a) Tea Master					
	i) Rotorvane	12:05	15 x 1	87	**208.33**	
	ii) CTC 1st Set	12:05	18.5 x 1	88	**254.02**	
	iii) CTC 2nd Set	12:05	15 x 1	87	**208.33**	
	iv) CTC 3rd Set	12:05	15 x 1	87	**208.33**	
	b) Steelsworth					
	i) Rotorvane	10:45	11 x 1	86	**137.50**	
	ii) CTC 1st Set	10:45	15 x 1	87	**185.34**	
	iii) CTC 2nd Set	10:45	15 x 1	87	**185.34**	
	iv) CTC 3rd Set	10:45	11 x 1	85.5	**137.50**	
					645.68	
3.	**Fermentation**					**0.046**
	Humidification Plant					
	i)Pump Motor	16:20	2.2 x 1	79	**45.49**	
	ii) Fan Motor	16:20	11 x 1	87	**206.51**	
					252.00	
4.	**Drying**					**0.140**
	a) Quality Dryer					
	i) Hot Air Fan	18:35	22 x 1	88.5	**461.96**	
	Motor					
	ii) Spreader Motor	18:35	15 x 1	79	**35.28**	
	iii) Output Motor	18:35	3.7 x 1	82.5	**83.34**	
	iv) Heater of TD Oil	18:35	10 x 1		**185.83**	
5.	**Sorting and Grading**					**0.055**
	a) Vibro Motor	21:50	1.5 x 6	79	**248.73**	
	b) Vibro Conveyor Motor	21:50	1.1 x 1	77.5	**30.10**	
	c) Vibro Conveyor Motor	21:50	0.55 x 1	62	**19.37**	
					298.20	

Table 5.4
Day 2: Electrical Energy Consumption

Sl. No.	Process	Duration (Hrs : min)	Motor Power Consumption x No. of Motors	Efficiency	Energy Consumed (KWH)	Energy Consumed Per Kg of Made Tea (KWH/Kg)
	Green Leaf = 11894 Kg				**Dry Mouth = 2720 Kg**	
1	**Withering**					0.1843
	Trough Motor	12.00	2.2 x 15	79	**501.27**	
2.	**CTC**					0.303
	a) Tea Master					
	i) Rotorvane	7:0	15 x 1	87	**120.69**	
	ii) CTC 1st Set	7:0	18.5 x 1	88	**147.16**	
	iii) CTC 2nd Set	7:0	15 x 1	87	**120.69**	
	iv) CTC 3rd Set	7:0	15 x 1	87	**120.69**	
					509.23	
	b) Steelsworth					
	i) Rotorvane	5:15	11 x 1	86	**67.15**	
	ii) CTC 1st Set	5:15	15 x 1	87	**90.32**	
	iii) CTC 2nd Set	5:15	15 x 1	87	**90.32**	
	iv) CTC 3rd Set	5:15	11 x 1	85.5	**67.15**	
					315.34	
3.	**Fermentation**					0.056
	Humidification Plant					
	i)Pump Motor	9:55	2.2 x 1	79	**27.61**	
	ii) Fan Motor	9:55	11 x 1	87	**125.38**	
					152.99	
4.	**Drying**					0.189
	a) Quality Dryer					
	i) Hot Air Fan Motor	8:05	22 x 1	88.5	**200.94**	
	ii) Spreader Motor	8:05	15 x 1	79	**15.35**	
	iii) Output Motor	8:05	3.7 x 1	82.5	**36.25**	
	iv) Heater of TD Oil	8:05	10 x 1		**80.83**	
					333.37	
	b) ECP Dryer					
	i) Blower Motor	9:34	1.5 x 1	79	**18.16**	
	ii) Hot Air Fan Motor	9:34	15 x 1	87.6	**163.81**	
					181.97	
5.	**Sorting and Grading**					0.055
	a) Vibro Motor	10:52	1.5 x 6	79	**123.80**	
	b) Vibro Conveyor Motor	10:52	1.2 x 1	77.5	**15.42**	
	c) Vibro Conveyor Motor	21:50	0.55 x 1	62	**9.63**	
					148.85	

5.3.3. Calculation of Thermal Energy Consumption

The data collected over the two days and the calculation of thermal energy consumption is shown below:

Day 1 (only Quality Dryer put to operation)

Green Leaf	= 23960 Kg
Dry Mouth	= 5461 Kg
Running Hour of Dryer	= 18:35 Hrs
Thick Diesel Oil Consumption	= 80 Lit/Hour
Therefore in 18.35 Hours TD Oil Consumption	= 1486.67 Liters
Calorific Value of TD Oil	= 10500 Kcal/Kg
Specific density of TD Oil	= 0.89 kg/liter
TD Oil Consumption	= 1486.67 x 0.89 = 1323.14 Kg
Heat liberated by 1323.14 Kg of TD Oil	= 1323.14 x 10500 Kcal = 13892970 Kcal = 13892970 x 4.186 KJ = 58155972.42 KJ (as 1 Kcal = 4.186 KJ) = 16154.44 KWH
Thermal energy consumed per Kg of made tea	= 16154.44 / 5461 = 2.96 KWH

Day 2 (both the dryers put to operation)

A. T.D. Oil (For Quality Dryer):

Green Leaf	= 11894 Kg
Dry Mouth	= 2720 Kg
Running Hour of Quality Dryer	= 8:05 Hrs
Thick Diesel Oil Consumption	= 80 Lit/Hour
Therefore in 18.35 Hours TD Oil Consumption	= 646.67 Liters
Calorific Value of TD Oil	= 10500 Kcal/Kg
Specific density of TD Oil	= 0.89 Kg/liter

TD Oil Consumption	= 646.67 x 0.89 = 575.54 Kg
Heat liberated by 1323.14 Kg of TD Oil	= 575.54 x 10500 Kcal = 6043170 Kcal = 7026.86 KWH

B. Coal (For ECP Dryer)

Running Hour of ECP Dryer	= 9:34 Hrs
Coal Consumption	= 40 Kg/Hr
In 9.34 Hr Coal Consumption	= 382.67 Kg
Calorific Value of Coal	= 5500 Kcal/Kg
Heat Liberated by 382.67 Kg of Coal	= 382.67 x 5500 = 2104685 Kcal = 2447.28 KWH

Now, Total Energy Consumed by both the Dryer = (7026.86 + 2447.28) KWH
= 9474.14 KWH

Therefore, Thermal Energy Consumed per Kg of Tea Manufacture
= 3.48 KWH

Section-wise energy consumption on Day-1 and Day-2 are shown in Table 5.5 and 5.6 respectively

Table 5.5
Section-wise Energy Consumption on Day 1

Section	Electrical Energy		Thermal Energy		Total Energy	
	KWH/Kg	%	KWH/Kg	%	KWH/Kg	%
Withering	**0.18**	**25**	----	----	**0.18**	**4.92**
CTC	**0.28**	**39.5**	----	----	**0.27**	**7.38**
Fermentation	**0.05**	**7**	----	----	**0.05**	**1.36**
Drying	**0.14**	**20**	**2.96**	**100**	**3.10**	**84.70**
Sorting & Grading	**0.60**	**8.5**	----	----	**0.06**	**1.64**
Total **%**	**0.71** **19.13**	**100** ----	**2.96** **80.87**	**100** ----	**3.66** **100**	**100** ----

Table 5.6
Section-wise Energy Consumption on Day 2

Section	Electrical Energy		Thermal Energy		Total Energy	
	KWH/Kg	%	KWH/Kg	%	KWH/Kg	%
Withering	**0.18**	**23**	**----**	**----**	**0.18**	**4.21**
CTC	**0.30**	**38**	**----**	**----**	**0.30**	**7.02**
Fermentation	**0.06**	**7.5**	**----**	**----**	**0.06**	**1.41**
Drying	**0.19**	**24**	**3.48**	**100**	**3.67**	**85.95**
Sorting & Grading	**0.60**	**7.5**	**----**	**----**	**0.06**	**1.41**
Total **%**	**0.79** **18.50**	**100** **----**	**3.48** **81.50**	**100** **----**	**4.27** **100**	**100** **----**

5.3.4 Estimation of Exhaust Losses

A. For Quality Dryer

Exhaust Temperature of Air from the Dryer : 140° F

Green Leaf = 23960 Kg

Dry Mouth = 5461 Kg

Running Hour of Quality Dryer = 18.35 Hrs = 66060 sec

Heat liberated by 1323.14 Kg of TD Oil = 58155972.42 KJ

Mass flow rate of the flue gas = $(\pi D^2/4) \times \rho_a \times \sqrt{2 \times g \times V}$

D= Diameter of the duct carrying flue gas = 0.525 m

V= velocity of flue gas = 62.08 m/s

Heat carried by the exhaust air = $(\pi D^2/4) \times \rho_a \times \sqrt{(2 \times g \times V) \times Cp \times (Tg - Ta)}$

= 592.04 KJ/sec = 39109891 KJ

for Ta= 30° C (Ambient temperature)

Therefore, heat used for drying = 19046081 KJ

% loss of heat = **39109891/58155972.42**

= 66.56 %

B. For ECP Dryer

Running Hour of the Dryer = 9:34 Hrs
= 33624 sec

Heat Liberated by 382.67 Kg of Coal = 8810211.41 KJ

Mass flow rate of the flue gas = $(\pi D^2/4) \times \rho_a \times \sqrt{2 \times g \times V}$

D= Diameter of the duct carrying flue gas = 0.336 m

V= velocity of flue gas = 34.53 m/s

Heat carried by the exhaust air = $(\pi D^2/4) \times \rho_a \times \sqrt{(2 \times g \times V) \times Cp \times (Tg - Ta)}$

= 181.11 KJ/sec = 6089618.1 KJ

for Ta= 30° C (Ambient temperature)

Therefore, heat used for drying = 2720593.3 KJ

% loss of heat = 6089618.1/ 8810211.41

= 69.12 %

5.3.5 Observations from the Experimental Study

The experiment reveals the following set of results:

1. Nearly 80% of the total energy consumed in tea manufacturing within the factory is thermal energy and 20% is electrical energy
2. Average electrical energy consumption per kg of made tea is 0.75 KWH and thermal energy consumption per kg of made tea is 2.97 KWH. So total average energy consumption is 3.72 KWH per kg of made tea.
3. Energy consumption depends upon duration of the whole process.
4. In descending order of electrical energy consumption in the different tea manufacturing processes are: CTC machine (37%), drying (24%), withering (23%), fermentation (8%), sorting and packaging (8%)
5. Drying is the only process where thermal energy is used.
6. In descending order of total energy consumption in the different tea manufacturing processes are: drying (87%), CTC machine (7%), withering (4%), fermentation (1%), sorting and packaging (1%)

7. There is exhaust thermal energy loss in the process of drying to the tune of 69.12 % in case of ECP Dryer and 66.56% in case of Quality Dryer.

The results on pattern of energy consumption in tea processing are shown graphically in Fig 5.2 and Fig 5.3

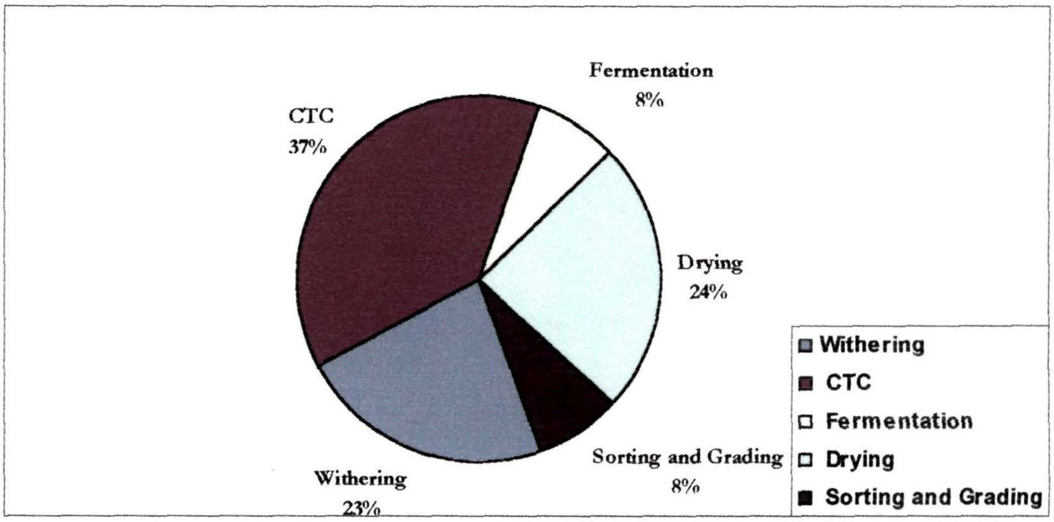


Fig 5.2
Electrical Energy Consumption Pattern in Tea Processing in Tea Factory

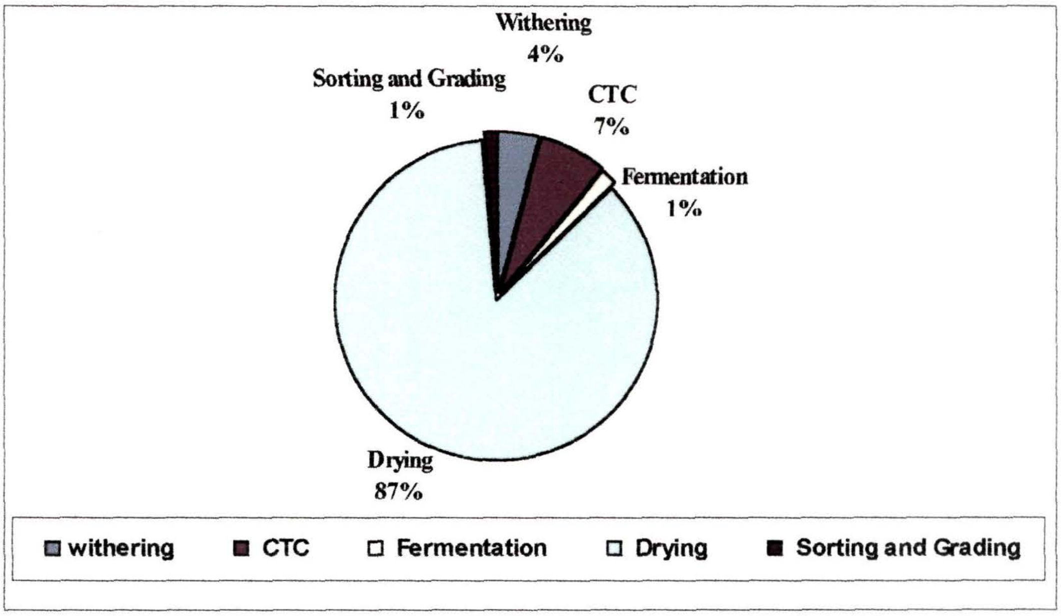


Fig 5.3
Total Energy Consumption (Electrical and Thermal)

Figure 5.4 depicts the results obtained in terms of loss of thermal energy in the drying process.

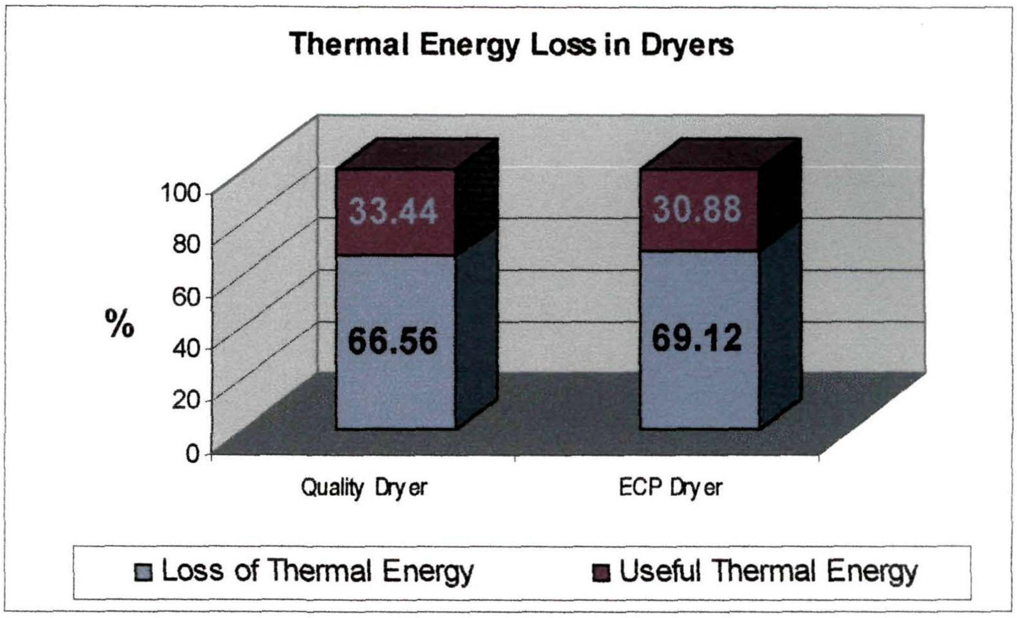


Fig 5.4
Thermal Energy Loss in Drying Process

5.4 Conclusion

It has been observed that the scope of further reduction in consumption of energy rests only on reduction of the exhaust losses. But there is a constraint in reducing these losses below a particular value as the made tea has to be discharged at a moisture content of 3%. Traditional dryers are in use in many tea gardens of Assam for many decades. The efficiency that can be obtained in such dryers in relation to operating parameters is very low (as seen in the experiment).

In many Industries where dryers are employed for drying of the product, recirculation of the exhaust air is made and is used as a convenient means to increase the thermal efficiency of the dryers and thus fuel is saved. But in case of tea it has always been considered taboo to even consider such a proposition (Roy Choudhury, S. N., 1997). It is thought that moisture present in exhaust air would adversely affect the quality of the tea dried. So great care is taken to ensure that the exhaust air is led out as directly as possible and that no part of it come in contact with fresh air entering the dryer heaters.

In the face of mounting fuel costs, it has now become necessary to have a fresh look into the matter and to find out whether or not recirculation of the exhaust air can be used with advantage in tea drying also.

5.4.1 Additional Observations Related to Energy Saving in Drying Operations

A. Each dryer and dryer system should be monitored carefully to ensure optimum fuel consumption

B. As the moisture content of fuel influences the calorific value of the fuel, protection of solid fuel from rain would help in reducing fuel consumption.

C. All equipment should be operated at the highest efficiency which will reduce the specific energy consumption.

D. Proper planning and management during the lean period will save energy and reduce production cost.

E. Training, man power development and efficient management of the factory personnel will reduce the production cost.

F. The thermometers should be periodically checked.

G. The dryer trays should be cleaned every time before the drying is started.

H. Instrumentation and measuring instruments used to monitor energy related parameters have to be of high quality and periodic checking is to be done to ensure their correct functioning. This is because, a faulty indication will lead to high fuel consumption and bad quality of tea.

CHAPTER- VI

Feasibility of TQM Initiation – A Case Study of a Tea Garden

6.1 Basis of Selection of the Garden for the Case Study

The garden selected for the study is an old garden with 100 years of existence, situated in the neighbourhood of Jorhat, the second largest city of Assam. The garden is a government undertaking and is one of the oldest gardens in the State of Assam, India. The garden has a glorious past of producing quality tea. The financial health of the garden is now in the downward trend. Presently the dimensions of the problems faced at all sections of the tea garden are becoming more complex with the shortage of fund. Apparently, such types of gardens are more constrained in terms of adaptability to change and operational flexibility. In most of the gardens in this region, there exists a similarity in life style and other socio-environmental conditions are also identical. Such a garden is a potential candidate to initiate quality movement which is likely to unleash all the complexities. Hence, a garden having such potentialities has been considered for observation. The objective of the survey was to asses the actual situation prevailing in the garden, so that TQM could be tuned based on the prevailing culture.

The size of human resource of the garden is also moderately large enough with around 600 employees. To initiate the quality system, there was a need to assess the environment in the garden. The scanning of the system was done through a feedback survey conducted at two levels, namely:

a) The Managerial Set
b) The Labourers Set

The set of Managers include Managers, Assistant Managers, Welfare officer and Supervisors. The set of labour force includes labourers engaged in garden and factory. In designing the questionnaires, help was taken from direct observation of system, interactions and conversations, formal and informal interviews at individual level. All the major dimensions, as perceived by the managers and labourers have been given due consideration in assessing the quality dimensions.

Details of the respondents in terms of departments and sex for both managerial set and the labour set, who participated in the study, are given in Table 6.1.The objective of the survey was spelt out to them to obtain their sincere participation. Sincere effort was made to develop a feeling in them how their responses could help in designing a system that is compatible to the culture prevalent in the system. To keep the anonymity of the respondents, no personal identity in the form of name of the garden, respondent's name and designation, department etc. was noted, so that any fear-psychosis likely to engulf the minds of the participants for the information passed on was removed. Classification of respondents is given in Table 6.1.

Table 6.1
Classification of Respondents

A. Classification of Labour Set		
	Frequency	**Percent**
Department wise		
Factory	22	35.5
Garden	30	48.4
Others	10	16.1
Total	62	100.0
Sex wise		
Male	48	77.4
Female	14	22.6
Total	62	100.0
B. Classification of Managerial Set		
Manager	1	16.7
Senior Manager	1	19.7
Asstt. Manager	2	33.3
Welfare Officer	1	16.7
Doctor	1	16.7
Total	6	100.0

The questionnaire was designed after interaction with both the groups falling under the categories as mentioned. It enabled the researcher to cover all the facets of the organization. Since many of the Labourers had low educational background, they were interviewed at personal level for their verbal responses. There were questions subjective in nature. The respondents were asked to disclose their views on the questions.

6.2 Designing the Survey for the Set of Labour Force

The labour force constitutes about 98% of total employees. They form the major category of stakeholders. So, their feedback is very essential to understand the environment in the garden. The objective of the survey and the importance of unbiased response of the respondents for sound footing of the quality movement were made clear to them. The broad aspects of the questionnaire were:

a) Quality of Managerial Set
b) Expectation on Welfare Activities
c) Facilities Provided
d) Attitude and Dedication

e) Quality Consciousness

f) Relationship and Interaction With Others

There were a few questions pertaining to:

- Factors that Motivate, and De-motivate to Work
- Positive and Negative Aspects of the Garden
- Essential Requirements Immediately Needed for Development

Table 6.2 shows the age and experience of the respondents in the set of labour set.

Table 6.2
Respondents (Labour Set)
Age and Experience

	Minimum (years)	Maximum (years)
Age	20	57
Garden Experience	1	32

6.2.1 Feedback Summary of the Labour Force

Quality Assessment of the Managerial Staff: Quality of the Managers as 'leader' is excellent, as felt by the labour set. They are commanding, communicating and have got good image in the mind of the labourers.

Welfare Activities Expectation: The respondents feel slackness in welfare measures. Health care facility is not thought to be adequate. Availability of medicines in the hospital, good roads, maintenance and renovation of the labour residences, safety measures in factories etc. are considered to be indicators of degree of welfare activities. Timely payment of wages and bonus is considered to be another important indicator of welfare measures.

Facilities: The facilities available to this class of respondents include Canteen facility, free ration, labour club, playgrounds etc.

Dedication for Work: This group of respondents feels proud to be part of this garden. They do not feel that they are heavily stressed with their assigned job. But due to unhygienic living conditions general health of most of them is very poor. Sickness is a common phenomenon in them. This prevents them to be regular in their job. Almost all have got positive attitude towards their job.

Quality Consciousness: What makes the quality of tea is not known to this group. The basics of leaf handling during plucking for quality are traditionally maintained. Most of the respondents have got the idea that if they do the job assigned to them carefully it will lead to enhancement of quality of final made tea.

Relations: They expressed that they have very intra-cordial relations amongst themselves. A formal relationship exists with the Managerial Staff. As revealed, this group is not a part of decision making process. They expressed that they have formal close interaction at all levels of the management.

The factors listed by the respondents as motivators and de-motivators for working are given in Table 6.3

Table 6.3
Labour Force Feedback on Factors that Motivate/Inhibit Working

Factors that motivate you to work	Factors that de-motivate you to work
1. Good administration	1. Improper treatment by superiors
2. Good working environment	2. Non-attention to welfare activities
3. Co-operation	3. Inadequate salary
4. Timely payment of salary	4. Poor working environment
5. Timely payment of bonus	5. Accidents
6. Recognition for hard work	6. Improper work load distribution
7. Freedom to work	
8. Good ancillary facilities like health care etc.	

6.2.2 Inferences : Labour Force Responses

a) The labour force has got close association with the garden. They feel: - 'the garden is ours'.

b) The labour force believes:-'prosperity of the garden will bring prosperity to their life'.

c) The labour force can be motivated by initiating welfare activities/creating facilities for better community life.

d) The congenial atmosphere of:-**"to be better of"** prevails in the garden. Thus, the attitude of the labour force is positive. So resistance to cultural change will be minimal.

Hence, a quality-oriented approach in the garden involving the labour force actively could possibly enhance the performance and avert the situation of present financial setback. As the major human resource segment of the garden is not advert to change, having a positive attitude, concerned about the well being of the garden, the garden seems to be a potential candidate for initiation of TQM Philosophy for its development as perceived by the set of labour force.

6.3 Designing the Survey for the Set of Managers

The Managerial set, though small in number, constitute the important part of tea manufacturing system. Improvement process cannot be initiated without their involvement; hence their feedback is most essential. The process adopted for the design of the questionnaire was identical to that of the labour set.

The Table 6.4 shows the age and experience of the respondents in the set of Managers.

Table 6.4
Respondents (Managerial Set)
Age and Experience in Tea industry

	Minimum	Maximum
Age	28	56
Garden Experience	1	27

The overall aspects of the questionnaire were:

A. Quality Assessment of the Labour Force
B. Resources Available in the Garden
C. Workload
D. Satisfaction, Career Growth
E. Relations
F. Decision Making Process
G. The Stress on Quality Aspect
H. Quality Policy, if any / Awareness on Quality

Some other questions on which their views were sought are related to:

1. Positive and Negative Aspects of the Garden
2. Essential Requirements Immediately Needed for Development

6.3.1 Summary of the Feedback from Managers

Quality Assessment of Labour Force: Quality of the labour force has been poor in terms of level of education. But in terms of skill they are sufficiently good. They lack in general awareness and communication skills. Most of them lead a social life lacking hygiene. Absenteeism is a common phenomenon for a sizeable portion. The permanent labourers are least motivated for work and the temporary workers are more motivated.

Resources Available in the Garden: The resources in terms of cultivable land, factory, labour force have been satisfactory. The factory is well equipped with all the machineries of tea processing but is old.

Work Load: The managers are traditionally accustomed to heavy work load and are not unhappy with it. During peak production period, induction of additional managerial level staff is felt. As tea industry is an old industry with minimum change, traditionally no one feels the severity of their workload.

Satisfaction: Managers have the zeal to take up any additional responsibilities. It is supported by their satisfaction in tea profession. Being a garden of weak financial health, the question of career growth for the individuals in the garden under study was beyond imagination at the time of the study.

Relations: The environment in the garden is such that there used to be very formal interaction between the managerial staff and the other group. The development of informal relationship with the managerial level is low due to the presence of class system in this industry. Intra-group interaction has been better. The orders of the managerial level people are strictly followed by the labour force. Hence the environment is congenial for setting up the quality assurance mechanisms in the system; through cultural transformation on this aspect.

Decision Making Process

Participation of down level people in decision-making process is low. Decisions are taken in the managerial level. The involvement of labourers in the process of decision making is a rare phenomenon. Most of the decisions are made by the top-most manager and passed on to the junior level managers and supervisory staff.

The Stress on Quality Aspect

It is rather interesting to know that the tea garden management lacks in the systematic knowledge of the factors which finally affect the quality of tea. The standards for different processes are set traditionally and are followed by all. Quantity (converting/processing the plucked leaf to made tea in the day) is much more important than quality, especially in peak seasons.

Quality Awareness: For the Managers, the awareness about ISO 9000 & Total Quality Management (TQM), Learning Organization & Knowledge Management, Quality Circles, has been significantly low, but as indicated, the interest for change exists. In this aspect, the question of survival in the present day competitive world is the motive force. Hence, before quality initiatives are undertaken, training on the basics of these concepts needs to be imparted to them. The application and the relevant benefits of these concepts should be emphasized for effective implementation of quality initiatives.

Other Amenities: The amenities like health care, subsidized ration, Staff/Labour quarters, recreational and other avenues in the garden are also considered. For labourers there exists playgrounds, clubs, community hall, a 10 bedded hospital with a doctor and other staff. For Managers the recreational club is common to a group of gardens. These too are essential, but the developments in these areas are very slow.

The other findings on changes for improvement suggest the following actions:

1. Quality based standards for all the processes involved in tea production
2. Stress on maintenance activities
3. Training on quality aspect of tea processing
4. Reduction of waste of heat in tea processing
5. Educating the labour force
6. Modernization of the factory
7. Enhanced interaction and freeness between the managerial set and labour force
8. Recognition for good work

The feedbacks from both the groups indicate that some motive does prevail among all employees for continuous improvement. This can be strengthened through a well-designed program on quality and cultural transformation. This needs to be systematized and integrated into the garden culture. Table 6.5 shows the perception of positive aspects of the garden as perceived by both the sets of labour force and managerial force.

Table: 6.5
Perception of Positive Aspects of the Garden

Managerial Set	Labour Force Set
1. Huge area for cultivation (provision for expansion)	1. Available garden area
2. High capacity production system	2. Good management
3. Huge labour force	3. Good infrastructure
4. Skilled workers	4. Qualified supervisors
5. Commitment of managerial set	5. Good factory
6. Fairly good Infrastructure	6. Good interaction
7. Ideal location of garden (not far away from City)	7. Good discipline
8. Nearness to Assam Agricultural University and Tocklai Tea Research Center	
9. Good factory & working Environment	
10. Good garden hospital	

The positive aspects as revealed by both the sets of Managers and Labour force include: - availability of huge garden area, good management, good infrastructure, qualified managers, workers and supervisors, good factory, good Interaction. These form the basic tenets for TQM. Hence the environment is congenial for its implementation. Table: 6.6 shows the perception of negative aspects of the garden as perceived by the sets of labour force and managerial force.

Table 6.6
Perception of Negative Aspects of the Garden

Managerial Set	Labour Force Set
1. Old machineries	1. Lack of informal interaction amongst managers and labourers.
2. Poor educational level of workers	2. Poor welfare measures
3. Absenteeism of workers in their job	3. No recognition for hard work
4. Lack of motivation	4. No scope of self development
5. Not far away from city (causes absenteeism)	5. Shortage of residences
6. Poor machine maintenance activities	6. No proper maintenance of allotted residences
7. Waste in production	7. Machines are old
8. Improper layout of machines	8. Irregular salary payment
9. Poor re-plantation rate	9. Irregular and inadequate bonus payment
10. No proper planning	10. Poor transportation facility
11. Involvement of workers in politics	
12. Security to life and property	

The negative aspects can be tackled by systematizing the garden activities, which is feasible from the TQM perspective. Both the sets are keen to undergo personal up gradation, which in itself is a positive indication for desire for change. There is a need to improve the education level and level of skill of the set of labour force. This improvement can also be effectively attained by implementing the concept of 'continuous improvement' of TQM philosophy. Table 6.7 shows the feedback on the essential requirements needed for garden development.

Table 6.7
Feedback on the Essential Requirements Needed for Garden Development

Feedback from	
Managerial Set	**Labour Force Set**
1. Use of high yielding variety 2. Use of standard insecticides, weedicides and pesticides 3. Development of maintenance schedule for all the machineries used in tea production 4. Identification of waste areas of tea manufacturing 5. Making the production system more energy efficient 6. Inspection for quality 7. Result oriented planning 8. Need of a good information system on tea 9. Need for upgraded amenities 10. On-job training for all 11. Application of new concepts of management for the industry 12. Imposition of reward oriented appraisal system 13. More finance for development 14. Enhancement of motivation level 15. Effort for reducing/optimizing energy consumption (Review of energy management)	1. Sophisticated infrastructure 2. Timely salary 3. Good administration 4. Training for better work 5. Accident- free operation 6. Proper maintenance of existing facilities 7. Better infrastructure 8. Better job guidance

6.4 Conclusion

The feedback from both the Managerial Set and the set of labour force of the garden reveals that the garden environment is conducive for implementation of quality movement. This revelation is substantiated by:

1) Supportive management for growth of the garden
2) Decline of tea market
3) Coming up of small tea growers in upper Assam region
4) Increase in cost of fuel

5) Enhancement of compulsory labour welfare measures as per Plantation Act leading to higher cost of production
6) Unstable environment due to irregularity of bonus payment in most of the garden in the State
7) Cohesive environment in the garden for growth, and also desire for self-improvement by the employees

As the organizational structure, culture, process of production, environmental conditions etc. for almost all the gardens operating in this State resemble with each other, it can be inferred that TQM is the need of the hour for the gardens to improve their performance with a cultural transformation. The subsequent chapters deal with the aspects for all-round improvement in the system of production of tea.

CHAPTER – VII

Development of Total Quality Management Indicator (TQMI) and Performance Indicator (PI) for Tea Gardens

7.1 Introduction to TQM Indicator (TQMI)

Generally, the performance of any industry is assessed in terms of its profit generating capacity, demand for their product, the input-output assessment i.e., productivity etc. The conventional assessing tools lack the indication of all the aspects, as demanded by the concept of Total Quality Management. As shown in Fig 7.1, TQM demands

- Commitment to quality
- Continuous improvement
- Total involvement
- Scientific tools and techniques

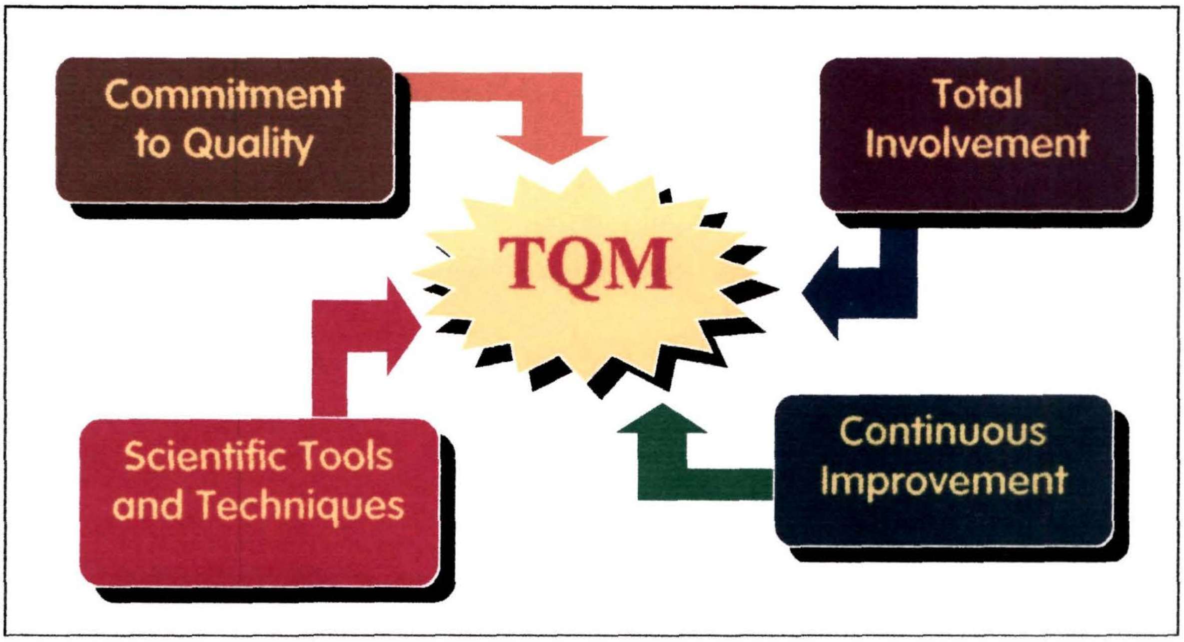


Fig 7.1
Basic Elements of Total Quality Management

TQM indicator is a concept thought to cover all the above requirements. This would serve as an appraisal tool for assessing the current status of any organization using TQM philosophy. The degree of improvement achieved by any organization can also be ascertained using this concept. This indicator is the final result of interaction of all the factors of the system.

Any system can be divided into different sectors or sub-systems. Each of the sectors or subsystems can again be sub-divided into different sub-sectors or smaller sub-systems. The ultimate output of any system is the result of interaction of all the variables in the sub-sector level. The primary requirement for identifying the interactions as mentioned above is to view the industry as a system with specified boundary. Identification of the sub-systems can be done based on operational/ functional/ behavioural similarity. The causality analysis of factors (Chapter IV) which directly or indirectly affect the quality of output provides an idea of the nature of interaction. The TQM results are dependent on the degree of these interactions. The results of TQM are mainly intangible in nature. These intangible results of TQM are reflected in different forms- financial, social, environmental, process of output and so on (Fig 7.2)

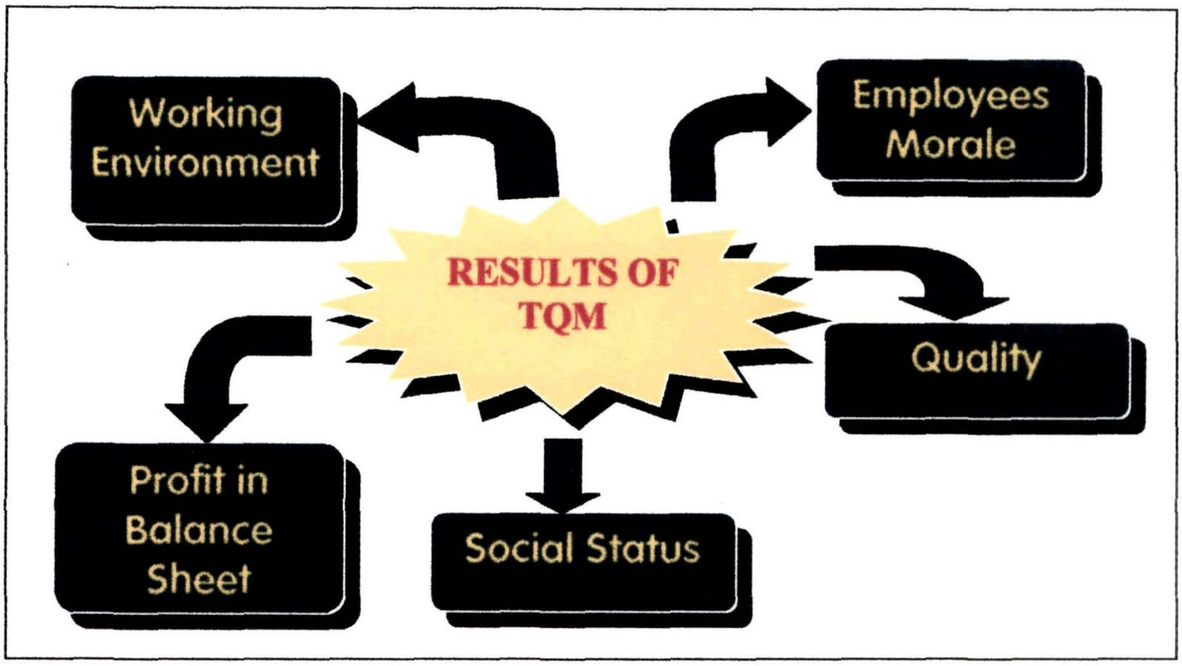


Fig 7.2
The Tangible and Intangible Output of Total Quality Management

The TQM Indicator, as proposed in this thesis, is a quantified value of the final output of the interactions at different sub-system levels showing the degree of TQM culture prevailing in an organization. An attempt has been made to develop the concept of TQM Indicator for Tea gardens using Systems philosophy. The subsequent topics deal with the building blocks for development of the Systems Performance model for a tea garden incorporating the concept of TQM Indicator.

7.2 TQM Indicator for Tea Garden Performance Assessment

In Tea Industry, the indicator used for describing the performance in an accounting period is the price realized by the product in the auction market. Sometimes the volume of production is also considered as the garden's indicator of performance.

It has been revealed in the previous chapter that the people in tea industry do feel that there are a lot of activities to be undertaken for development of a garden apart from merely enhancing volume of production and producing high priced tea. Based on the feedbacks received for improvement of functioning of the garden (Chapter VI), an attempt has been made to segregate the tea garden into different sub-systems having operational, functional or behavioural similarity.

As elaborated in Chapter IV, the segregation is based on the factors which affect the final output of a tea garden.

7.2.1 System and System Boundary

The whole tea garden is defined as the 'system' for analysis. All the sectors that are integral to a tea garden are considered to be the elements within the system.

Thus the tea garden is divided into seven sectors based on operational/ functional/ behavioural similarity. The sectors are:

1. **Human Resource Sector**
2. **Processing Sector**
3. **Maintenance Sector**
4. **Management Sector**
5. **Energy Sector**
6. **Field/Garden Sector**
7. **Welfare Sector**

All the sectors have intra-interactions and thus the performance of one enhances or reduces the performance of the other.

All the other elements falling outside the boundary of the system constitute the 'environment'. The elements falling under this category include:

- Government
- Suppliers
- Competitors
- Customers
- Society

The elements of the 'environment' decide the desired route along which the performance of the garden is to be directed. Any change in these factors would affect favourably or adversely the performance of the garden. The elements, which are uncontrollable, are exogenous variables in respect of the system. The 'environmental factor' as illustrated in chapter IV is considered to be the exogenous element in respect of the tea garden system. The system or the 'environment of the system' does not have any control over the exogenous element. Fig 7.3 depicts the tea garden system. The interaction of all the sectors would result in a particular state of performance of a garden. The current state may be improved by putting attention to each of the sectors.

The performance of any sector may be specified by the Sector Performance Indicator (SPI) when each sector is considered in isolation. Assessment of sector-based indicators would lead to assessment of problem areas needing more attention for improvement. The values of SPIs will be used in calculating the value of Performance Indicator (PI) for tea gardens which is also a function of Total Quality Management Indicator (TQMI) and Base Score (BS). Discussion on calculation of PI has been presented elsewhere in the thesis.

As TQM itself demands continuous improvement, the improvement in each sector for organizational growth is essential on continuous time scale. The SPIs with reasonable weightage assigned, results in the TQMI of a garden.

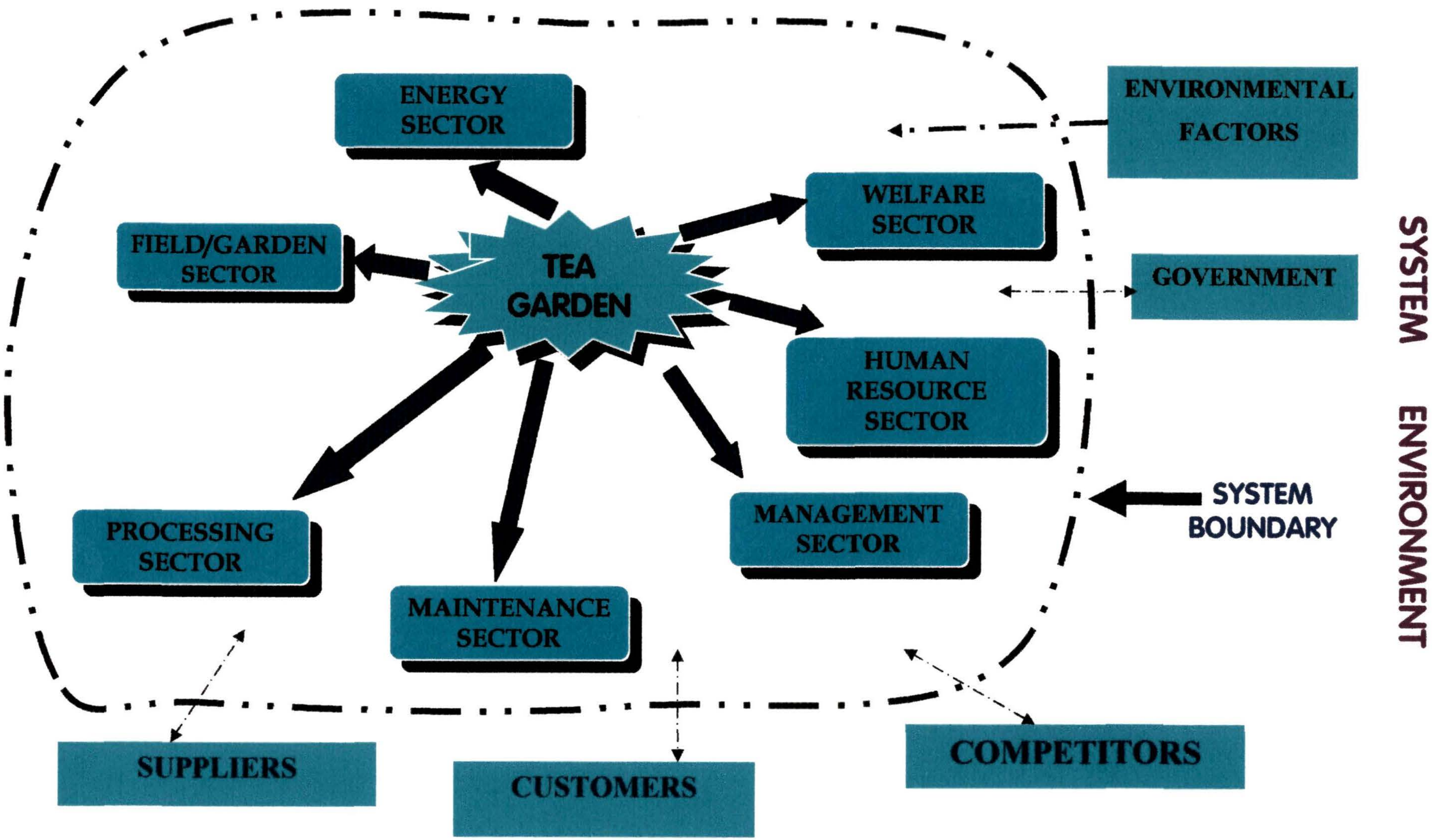


Fig. 7.3
Tea Garden as a System

The aspects covered by the proposed TQMI for a Tea garden are shown in Fig. 7.4.

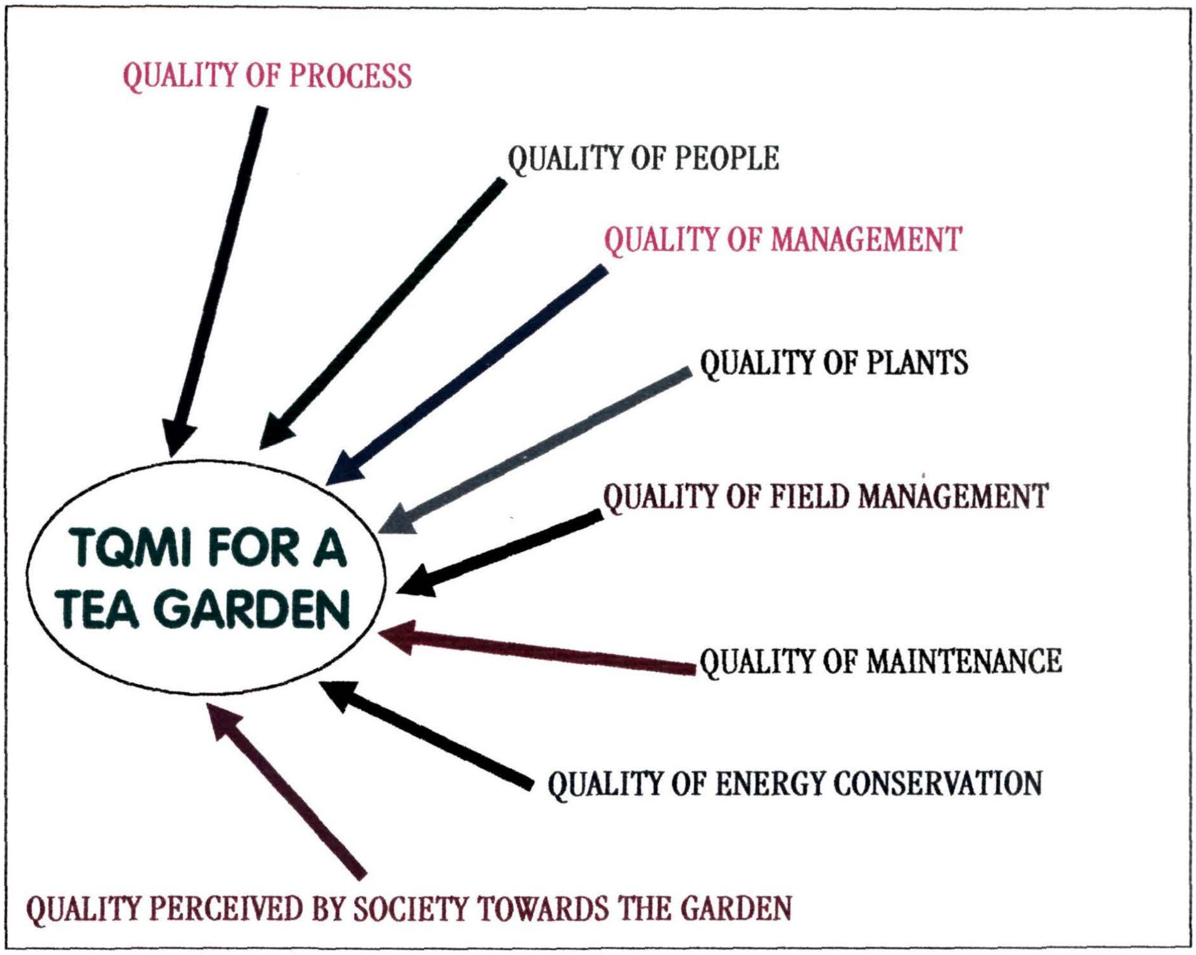


Fig 7.4
The Aspects Covered by the Proposed TQMI for a Tea Garden

Continuous improvement efforts normally result from appraisal of states. The desired state in continuous improvement process is dynamic in nature. The system, in the process of attainment of a desired goal behaves dynamically. The process is depicted in Fig. 7.5

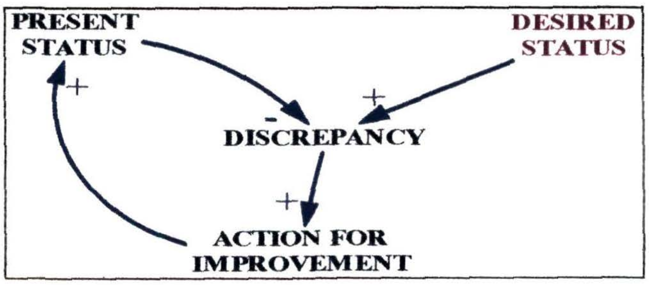


Fig 7.5
System Status Improvement through Sector Analysis

7.3 The Area and Scope of Application of TQMI in a Tea Garden

TQMI is a quantitative value of present status of TQM culture in a garden developed on the basis of factors affecting quality of made tea. The absolute value representing the TQMI of a garden would prove to be useless if treated in an isolated manner. TQMI, as proposed, is a tool for measurement of Quality in totality. The proposed TQMI would benefit the tea estate managers, proprietors and Board of Management of tea Company by providing new well-grounded information for more effective quality management practices.

It has been observed that most of the Companies having proprietorship of tea estates in Assam have more than one garden (Refer Tea Directory of 'Tea Information System', Chapter IX). The tea produced in the various gardens under the same plantation company varies in terms of price in the auction market. TQMI may be an effective tool for evaluating the performance of the gardens by the top management and pin-point the weak areas where much effort will be required for improvement. These weak areas will be depicted by the SPIs of the model.

Moreover, the price realization by the produce of a particular garden in auction market varies from time to time. A garden realizing high price may not be able to sustain its quality for same/higher price realization in the future if systematic evaluation of performance is not carried out. TQMI may prove to be an important tool for identifying the reasons such inconsistency.

7. 4 Sectors of Tea Garden System

As mentioned in § 7.2.1, a tea garden system can be segregated into seven sectors. The aspects covered by different sectors (sub-systems) of tea garden system are discussed below:

7.4.1. Human Resource Sector

This sector deals with the available manpower in a tea garden. Normally in a tea garden two broad categories of employees are there- Workers and Managers.

7.4.1.1 Classification of Workers

The standing orders (Appendix – A) as formulated and approved by the Labour Commissioner, Assam for the Member Tea Estates of Assam Tea Planters' Association (ATPA) under the Standing Order Act 1946 have classified the workers as under:

1. **Permanent Worker:** A workman who resides in the Tea Estate and whose name is entered in the Estate's Roll of workers and includes any person who has completed probationary period of 8 (eight) months in the same or any other occupation in the Industrial establishment, including breaks due to sickness, accidents, leave, lock-out, strike(not declared illegal) or involuntary closure of the establishment
2. **Probationer:** A workman who is provisionally employed to fill a permanent vacancy in the post and has not completed eight months of service therein.
3. **Outside Worker**: A Worker who resides outside the Tea Estate but whose name is entered in the Estate Roll of Workers, provided that one who is regular and whole time worker, shall not be deemed to be an outsider for the purpose of clause 9(b) of the Standing order. Clause 9(b) deals with termination of employment and notice thereof to be served. This clause states- " Notice of termination of employment shall be necessary only in case of permanent workers and not in the case of outside or temporary workers except in so far as is laid down in any agreement entered into between the Manager and such outside or temporary workers.
4. **Temporary Worker**: A worker who has been engaged for work which is of essentially temporary nature and is likely to be finished within a limited period.
5. **Learner**: Worker who is employed on probation by the Manager and who may be paid a nominal wage during his period of training.

7.4.1.2 Categorization of Plantation Workers

Prior to the implementation of the Central Wage Board's Recommendation on 1.4.66 there were no standard occupational nomenclatures in the Tea Plantations. All employees employed in the Tea Plantation were used to be identified as Field Workers, Factory Workers, Office Staff, Hospital Staff, Workshop Workers, Sirdars, Chowkidars etc.

The Central Wage Board for Tea Plantation Industry, 1966 brought all employees working on the Plantation itself or at any place in the Tea Plantation District and coming within the definition of "Workman" of Industrial Disputes Act – 1947 under the banner of "Plantation Workers".

The Central Wage Board for Tea Plantation Industry also standardized the nomenclature of the employees and recommended from 1.4.66 the following broad categories of employees in the Tea Plantation Industry.

A. Daily Rated Workers
B. Sub-staff and other monthly rated workers
C. Clerical Staff
D. Medical Staff
E. Artisans and Technicians

The grades of these categories of employees are shown in Appendix-IV-A.

7.4.1.3 Managerial Level Employees

Generally in a garden, following cadres of managerial level employees are seen:

- Senior Manager (depending on the size of the garden)
- Manager
- Assistant Managers (Garden and Factory)
- Welfare Officers
- Group Engineers (for a group of gardens)

This sector takes care of the total number of persons employed in the garden, factory, office and other supporting units of the tea garden. The permanent, semi-permanent and temporary employees are specified within the circumference of this sector. The sector indicator for this sector brings into notice the amount of money spent on salaries and wages of the employees of the garden for 1 Kg of tea produced.

Tea is not only bushes, it is also people. As TQM demands for good quality people for vibrant quality culture in an organization, no garden can ignore all round development of the people within the system. The close loop reaction between improvement of employees and improvement of garden finally results in a vibrant quality culture in an organization.

The labour plays an important role in tea industry and the expenditures on this factor is almost 50-55% of the cost of total tea production. In an environment, where according to conventional strategic analysis, other sources of competitive advantage has always changed over time, the human factor seems to be stable and a reasonable ally. As a result of increasing pace of change, the growing importance of knowledge and creativity and the necessity to decentralize, it seems obvious that the human factor will become more important in near future. This SPI for HR sector attempts to find the degree of achievement in these aspects.

The number of employees serving in a garden depends on the size and health of the garden. There may be gardens which are having employees less than the number required. On the other extreme, some gardens may have additional labour forces proving to be unproductive. This SPI also deals with this aspect while assessing the performance of this sector.

In addition, this sector deals with the level of education of the employees at different positions and evaluates the discrepancy in this aspect.

The 'experience factor' in tea production is very important. An experienced worker or manager proves to be an asset of the garden. This sector takes care of this aspect also.

As already stated, employment of child labourers is an illegal offence. At the time of scarcity of labour, some gardens put child labour in job temporarily. This performance indicator takes care of this aspect too.

Other aspects that are taken care of in this sector are:

- adherence to payment of salary as prescribed by Plantation Labour Act
- rate of bonus payment to the employees
- timely payment of salary
- timely payment of bonus

7.4.2. Energy Sector

Tea industry consumes energy in two forms- electrical and thermal (Chapter V). Electrical energy is used for lighting purpose in gardens bunglows, labour quarters, hospitals, roads, factory etc. Tea processing uses large amount of thermal and electrical energy. Electrical energy is required to run the rollers/ CTC machines, withering fans, dehumidifiers etc. Thermal energy is used to remove the moisture during drying and withering process. The requirement of electrical and thermal energies depends upon the manufacturing practices, leaf standards, and extent of mechanization. (Rodrigues, E., 1997).

The fuels used in tea processing are:

- Gas and oil
- Coal
- Fire wood (Very sparingly used)
- Leco (Used in South India)

In its initial stage, tea industry was dependent on coal for the energy needed for various purposes. In the sixties of the last century, the gardens switched over to oil for convenience of storage, handling, burning and for cleaning purpose. Das (1997) observes that in Assam, compared to coal firing, oil firing is 16 times costlier in withering and 2 times costlier in drying.

The Energy sector deals with all the aspects related to use of energy in all forms at different points of consumptions like:

- Factory
- Bunglows
- Labour Quarters
- Hospitals
- Other amenities viz. street lighting, community halls, clubs etc. under the purview of the garden administration
- Fuel consumed by the official vehicles (school buses, tractors, trucks, cars) and fuels issued to the employees (for vehicles) free of cost on monthly basis

Application of fuel efficient technology (mainly in drying process) results in minimization of level of energy consumption. The Energy Indicator takes into account such efforts by the gardens.

As discussed in chapter III, recycling of waste heat in tea manufacturing is not considered at all. The adoption of such efforts would lead to immediate benefit in the form of energy saving and hence in reduction of expenditures. In the long run, such activities would develop a sense of continuous improvement at management level. This aspect is also considered while developing the indicator for energy sector.

7.4.3 Maintenance Sector

Maintenance is an age old process which developed and progressed, knowingly or unknowingly along with the operation of the equipment. In early ages, maintenance was, probably, not a separate identity but the task of maintenance was considered as part and parcel of operator's job. This was possible because of simplicity and openness of machines and equipment. However, with the growth of Industrialization, the complexity of machines increased and machines became less simple and less open. This started creating problems for the operating personnel and the concept of maintenance as a separate discipline and separate identity started.

While developing the TQM model for a tea garden, the maintenance sector is viewed from two angles:

- factory maintenance
- maintenance of infrastructure of the garden

In the present scenario of the tea industry, there should be every possible effort for making the industry on-line with optimal cost technology. It has been felt that the aim should be to make the existing system much more efficient whether it's at factory level or management level. In studying the present status of tea production, emphasis has been given on the age old factory which requires much more maintenance in a methodical and systematic way.

In the visits to different tea estate factories, it was observed that:

- the tea machineries used by the gardens are old and their mechanism is simple
- experienced persons are normally involved with the operation of machineries
- a number of tea gardens do not have any daily/fortnightly/monthly maintenance schedule. The annual overhauling of the machineries is carried out in the lean season (during December to March) only

In contrast, maintenance is a vast and specialized subject in tea industry, especially in the factory. This sector has got direct and immediate effect on the other sectors of tea garden.

Maintenance is an important function of the tea estate. It is primarily concerned with making the productive Equipment and other capital assets available for use. Maintenance activities in the factory of a tea garden are affected by working conditions with respect to safety, the inspection procedure, and the duration of inspection, the type of instruction given by the maintenance supervisor to the mechanics or technicians, the work activities, proper maintenance of the engineering records, the size, setup and devotion of maintenance unit.

The traditional objective of maintenance in this industry is to avoid breakdowns of machinery during the manufacturing season (Ghose, 1999[2]). This is not at all difficult to achieve, if Planned Preventive Maintenance is practised. Proper maintenance records greatly benefit the factory staff. With the help of such records it is possible to establish the useful life of important machines and parts.

The tea garden maintenance programme should ensure minimum breakdown of resources and to keep it in good working condition at lowest possible cost. Machines and other facilities should be kept in such a condition which permits them to be used at their optimum (Profit making) capacity without any interruption or hindrance.

7.4.3.1 An Experimental Study for Preparation of a Maintenance Schedule for a Tea Garden

A study was conducted to determine the requirements of maintenance activities for various machineries used in a tea factory. The tea factory selected for the purpose is located in Golaghat district of Assam. Appendix II-A shows the list of various machineries in the factory of the garden selected.

The machineries and Equipment of the production system are classified into two categories:

1. Moving parts
2. Stationary parts

An effort has been made to prepare a maintenance schedule for these two categories of parts. The proposed maintenance schedule is shown in Appendix II-B. The proposed schedule is an attempt to streamline the maintenance activities and to make the management of the garden aware about the weak spots in the production system.

Apart from the maintenance of machineries of the factory, the maintenance of other infrastructure of the garden like, the factory building, residential quarters of managerial staff and labour force, hospital, community centers, garden owned schools, roads etc. are also important when viewed the garden system from its totality. In the proposed model of tea garden, this aspect has also been included.

The Maintenance sector also deals with the safety aspect in the areas:

1. safety in the factory
2. safety in field (hazards caused to the person engaged in application of weedicides, pesticides, insecticides etc)

The maintenance sector has a positive causality on all the other sectors of the garden. Continuous improvement in this sector enhances quality from TQM view point. Thus the maintenance sector is primarily concerned with the status of effort made by the garden for sustaining productive equipment and other capital assets.

7.4.4 Processing Sector

It is seen that all the processes involved in the tea processing; *viz.* withering, rolling, fermenting, firing(drying), sorting, grading, storage, and packing play an important role in building the quality of tea (Chapter III and Chapter IV). Careful and proper processing bring out the full potential of the green leaf.

In the processing sector, the major quality characteristics are imparted to tea. The positive functioning of this sector enhances the functioning of all the other sectors of a garden.

Thus, the processing sector takes into account

- the adherence to production standards in different processes of tea processing
- waste reduction efforts put into the process of production of tea
- the types of machineries used in the factory
- the age of the machines
- capacity utilization of the machines
- the layout of the factory (extent of material handling within the factory)
- the effort on modernization of machineries

7.4.4.1. A Study on Layout of a Tea Factory

An experimental study was conducted to assess the material flow pattern and the level of material handling within a tea factory arising out of its layout. The objective of the study was to investigate the presence of any flaw in the layout by estimating the material handling cost in terms of labourers involved in tea processing within the factory and the distance moved by in-process tea during production. An attempt has been made to propose some modifications in the layout. The benefits of implementation of the modifications are calculated in terms of reduction in labourers involved and distance of flow of in-process tea. While analyzing the benefits, no attempt has been made to calculate the pay-back period due to change in design of the factory layout. The tea factory selected for the purpose is located in Mariani of Jorhat district of Assam.

7.4.4.1a The existing layout and its drawbacks

The factory under study is a relatively modern. It is well equipped with modern machines like CTC, Vibro Fluidized Bed Dryer (VFBD), Presorters, Automatic Wayman scale etc. The existing layout of the factory is shown in Appendix II-C. As revealed by the Management of the garden, the main problems due to the exiting layout of the factory are:

1. high cost of material handling
2. long distance of material flow

It was also observed that excessive use of manual material handling results in increase of expenditure in terms of labour wages. This has affected the total production cost of the made tea.

7.4.4.1b Proposed modification of the existing layout

An attempt has been made to introduce a number of modifications to minimize the distance of flow of in-process tea and thus to minimize the cost of production. Following modifications have been proposed:

1. Shifting of withering trough chamber to a new location
2. Introduction of an overhead monorail for loading and unloading of withered leaves from withering trough and rolling machines respectively.
3. Introduction of conveyor from the CTC machines to the fermenting room

4. Design modification of the Drying, Sorting, and Grading rooms and introduction of a conveyor system

   The proposed modifications of the layout is shown in Appendix II-D

7.4.4.1c The effects of the proposed modifications

The modified layout resulted in the following

A. Material Handling Cost

- Reduction in size labour force per shift = 41 labourers
- Reduction in labour cost per shift = Rs.2029.50
- Reduction in cost of per kg of made tea = 0.25 paisa

B. Material Flow

- Reduction in distance of material flow = 174.0 ft
- % reduction in material flow = 22.44%

7.4.4.1d Conclusion of the study

The study has revealed that there is a scope for improvement in the layout of the factory. In most of the tea gardens of Assam, the layout in the factories has not been changed since the establishment of the gardens. With rising demand for quality tea at lower cost, it has become essential for the gardens to think for restructuring the layout for eliminating waste in different forms. This would result in lowering the production cost of tea and higher productivity of the gardens.

7.4.5. Field/Garden Sector

As discussed in earlier chapters, it can be inferred that good tea is the product of good leaf in the first place. Good tea leaf can be obtained from a healthy plant (Barbora, B.C. et al., 1984). This sector deals with all the aspects related to the factors responsible for upbringing a healthy plant for better productivity.

Since the quality of the tea depends upon the composition of the plucked leaf, so quality of tea is indirectly affected by the plucking interval. So plucking should be carried out at standard intervals. For producing good quality tea, leaf should be plucked with due care. This sector takes care of the aspect of standard of plucking.

The quality of tea is affected by the age of the tea plant. Generally tea quality improves with aging of tree and gradually decreases after reaching its maturity (Singh, I.D. et al.,1994). Usually plants with age more than 50 years become unproductive. It has been proved experimentally that bushes in the age group of 15 to 35 years are most productive (Awasthi, 1977). Re-plantation is an aspect which enhances the continuous improvement of the garden. The garden sector deals with this aspect of the garden.

Maximum utilization of available land and plantation density bear direct proportionality with the volume of production. This sector deals with this aspect too.

In case of Assam Tea, shading increases the yield and quality of tea. In Assam, shade reduces the natural light intensity by about 50% and usually increases the yield. (Phukan, B. C., 2002). This sector includes the management of shading trees also.

Experimental studies in the field of pruning reveal that proper pruning cycle is needed for better yield. This sector deals with the garden's adherence to its pruning standards.

Weed growth control in gardens is an important activity for better yield. Elimination of weed growth early in the season and during the period of active growth of tea bushes has a direct beneficial effect on the crop. This sector of the model deals with the effort made by a garden in weed control measures.

The use of fertilizers, insecticides, pesticides etc. in tea planting is often blamed for loss of quality. However, no garden can neglect these activities. The loss of quality due to presence of residue of these can be nullified by controlling the time of application, quantity and application practices etc. Strict adherence to standard Pest Control Calendar normally leads to successful protection against diseases of the plants. (Refer Appendix IV-D). This sector covers this aspect also.

Irrigation is another factor which helps in sustaining and maintaining the health of the bush. Proper drainage facilities implemented in the gardens prevents water logging which is detrimental to the health of the tea bush. The effort put by a garden in this regard is also taken care of in this sector.

Yield per hectare of tea depends on type of clone used, extent of field management activities, plantation density, pruning etc. This sector takes care of this aspect also. As discussed in Chapter IV, leaf treatment plays an important role in building the quality of made tea.

Another aspect, as was discussed in Chapter IV, affecting quality of made tea is the cultural factor. This sector of tea garden system deals with these aspects too.

Thus, Field or Garden sector deals with the following aspects of a garden:

Fertilizing, Drainage, Shading, Pruning, Irrigation, Weed control, Pest management, Yield, Leaf treatment factors, Cultural factors, Land capacity utilization, Re-plantation, and Plantation density

The performance of this sector results in quality input to the production sector.

7.4.6 Welfare Sector

Welfare activities undertaken by a garden may be classified into two categories:

1. welfare activities as prescribed by law for the labour force of the garden
2. welfare activities undertaken by the garden towards society (an element outside the garden system)]

The adherence to the first category of activities enhances the level of satisfaction of the stakeholders of the garden and the second builds the faith and goodwill of the society towards the garden. Appendix IV-C presents the mandatory welfare activities as prescribed by law for any garden.

This sector is concerned with the standard of life of the employees in tea gardens and inhabitants of adjoining areas and the garden's effort to enhance it. It falls in the purview of business ethics for a garden to think about its people's welfare to the maximum possible extent. Apart from it, a garden can never stay in isolation from the society outside the garden. In an underdeveloped state like Assam, tea industry must have to sit in driver's position for development of the state. This indicator brings out a garden's contribution to these aspects too. The effect of this sector indicator is obtainable in the long run. Continuous improvement in this sector, in the long run, would result a precious sense of 'goodwill' in people's mind towards the garden.

7.4.7 Management Sector

TQM philosophy deals with cultural transformation. As pointed out in Chapter II, the main reason of failure of TQM implementation in any organization is the lack in commitment of management and their resistance for change. Lot of problems, in any organization, are the result of management attitude and are created as a result of management actions. In tea garden also, it is expected that management must have to have zeal to improve. Open, transparent and participative management can only make an organization a "learning organization'. It has been experienced by the author that tea industry lacks in all these aspects. Rather than being open, this industry is much more 'closed' than other industries in this region.

This sector deals with the efforts of the garden to change the behavioral culture of its employees by way of enhancing the skill and morale of the employees. The factors like level of job-satisfaction, attitude towards the garden, sense of belongingness to the garden etc. come under the purview of this sector. Moreover, the Management Sector encompasses the factors like education and training, empowerment, participation and small group activities which boost the efficiency and morale of the work-force.

This sector also deals with the aspects of degree of openness of garden management for cultural change. The aspects of attitude of managers towards employees, the skill of the managers, the satisfaction level of managers etc. are dealt with in this sector of tea garden system.

The work culture in the garden comes under the purview of this sector. If management sector reinforces all the other sectors, a garden will rise to its zenith of success.

All the Sector Performance Indicators (SPIs) of the seven sectors which constitute the Tea Garden System contribute to the Total Quality Management Indicator (TQMI) as per their importance and relevance in a tea garden. The construction of a mathematical model leading to the single indicator, TQMI, incorporating Sector level performance of all the sectors using **'Utility Concept'** (Refer Appendix-III) is discussed below.

7.5 Classification of Factors

The factors that contribute to the SPI of a sector, as treated in this model, are of two types: **variables** and **attributes.** The factors which can be expressed in some **physical units** and are **tangible** in nature are categorized as Variables and others which have got direct/indirect impact on the SPI but are of **intangible** and **subjective** in nature or are **intentionally treated as intangible** are categorized as attributes.

The steps involved in the calculation of the SPIs is shown pictorially in Fig. 7.6

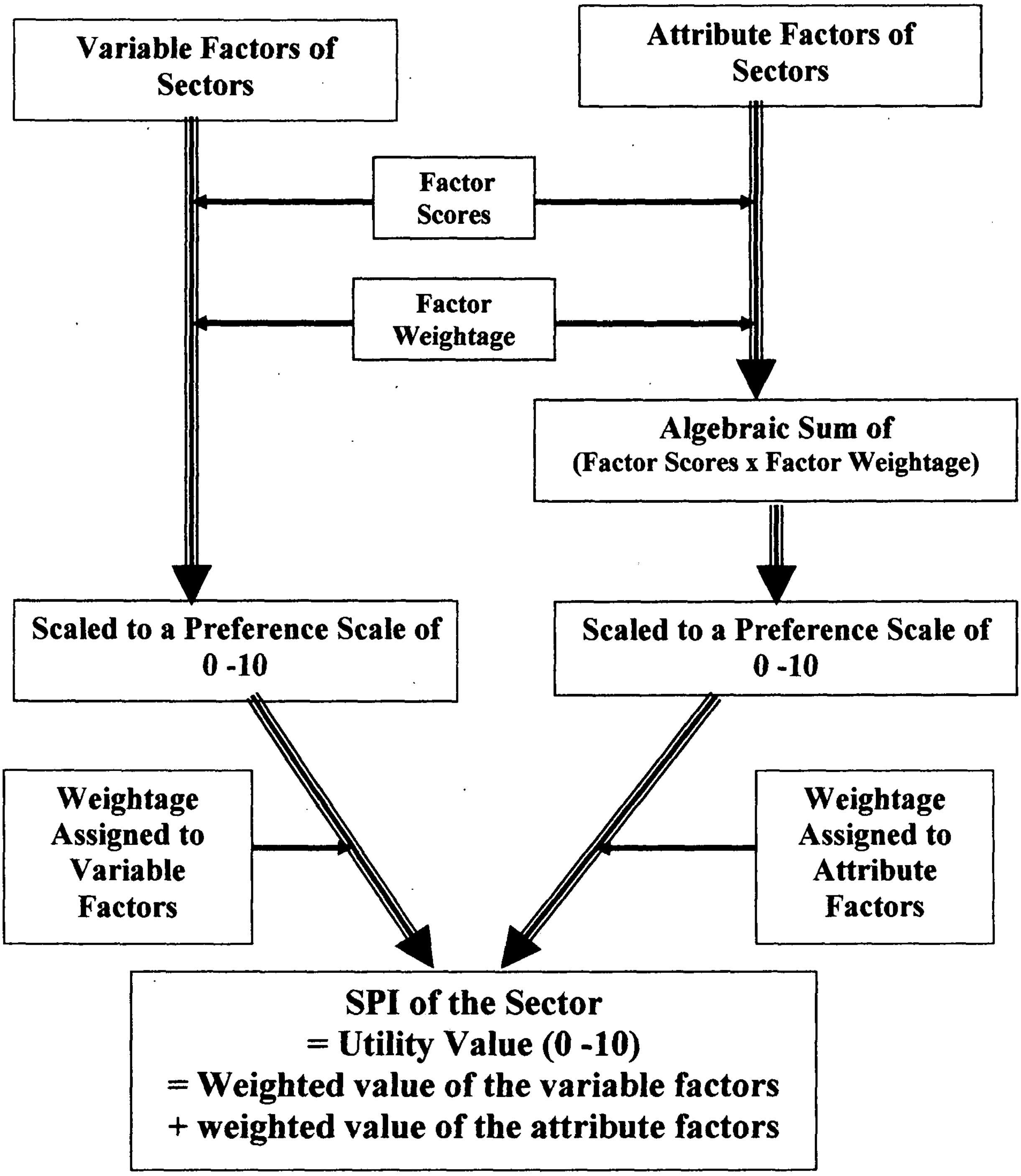


Fig. 7.6
Method of Computing Sector Performance Indicator (SPI) of Individual Sectors

As already discussed, the TQMI is the ultimate effect of all the SPIs. All the seven sectors of a tea garden, as segregated in this model, do not have the same impact on the TQMI. TQMI is considered to be the weighted sum of all the seven SPIs. It has been proposed to scale the TQMI in a scale of 0 to 10. The calculation for the TQMI is shown in Fig. 7.7

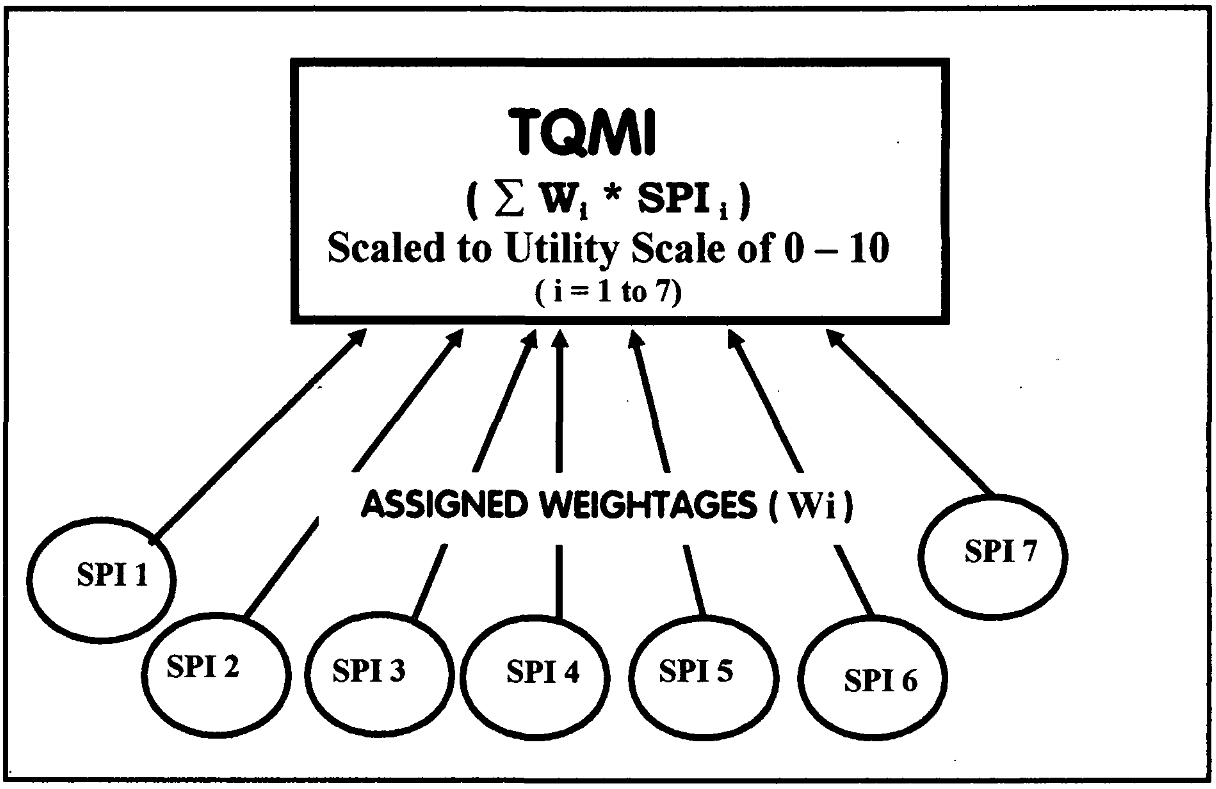


Fig. 7.7
Computation of TQMI from SPIs

7.6 The Performance Indicator of a Garden

The TQMI for a garden reveals the status of Total Quality Culture level of a garden in the computing Period. TQMI may be extended to assess the performance of a Garden in a period by incorporating the effect of factors, mainly environmental and genetic, as discussed in Chapter-IV. These factors, as discussed, are management uncontrollable and hence, the resulting effect between these factors and the existing TQMI would indicate the performance of a garden in a better way. In this model, a 'Base Score (BS)' is assigned to represent the environmental and genetic factors.

Thus the Performance Indicator (PI) for a Tea Garden in a computing Period is a function of 'TQMI' and 'BS'.

PI = f (TQMI, BS).................. (7.1)

Fig 7.8 shows the computation of PI of a Garden.

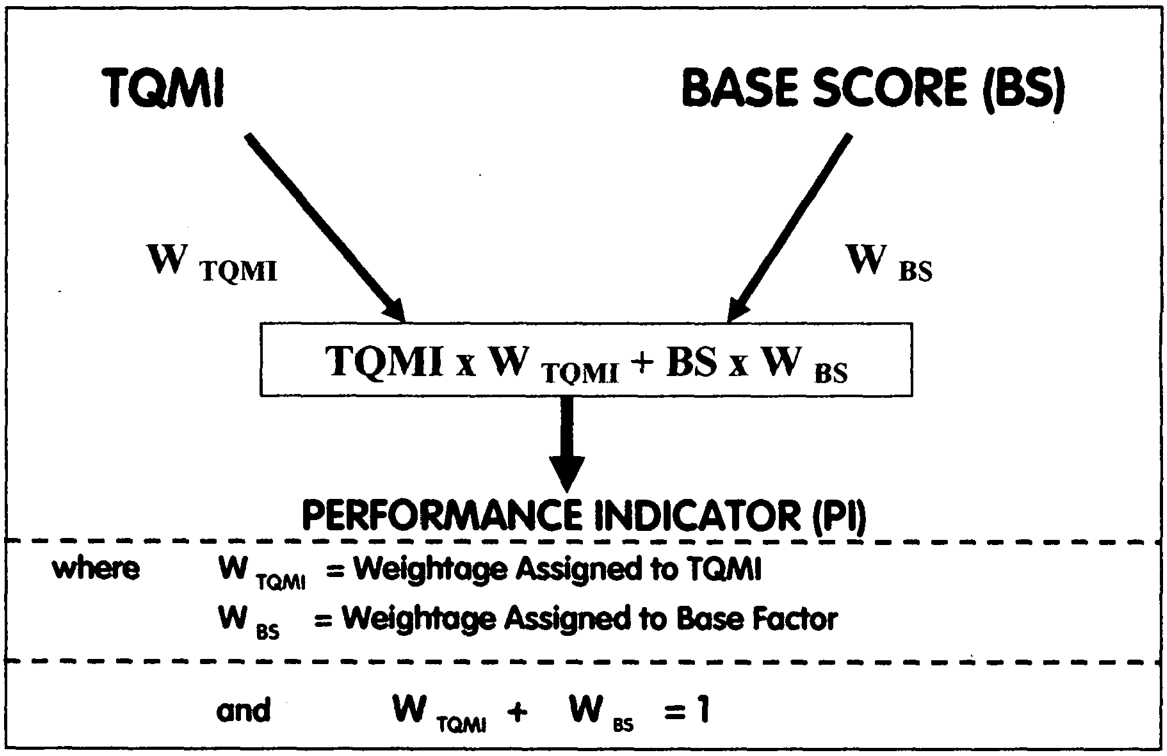


Fig 7.8
Computation of PI of a Garden for Computing Year

7.7 Global Factors for the TQMI

The factors which affect all the sectors of the tea garden are considered to be global factors. The global factors are given in Table 7.1

Table 7.1
Global Factors for the TQMI

Description of the Factors	Variable Name		
Total Production of the Garden in the Computing Period (Kg)	**CTC**	**CTC + ORTHODOX = PDN**	
	ORTHODOX		
Average Price Realized in Auction by the Garden Tea in the Computing Period (Rupees)	**CTC**	**PRCTC**	**(CTC x PRCTC + ORTHODOX x PRORTH) / PDN = PRA**
	ORTHODOX	**PRORTH**	
Total Area of the Garden (Hectare)	**AREA**		
Production Per Unit Area (Kg / Hectare)	**PPH**	**PDN/AREA**	
Total Expenses Incurred by the Garden in the Computing Period (Rupees)	**TOTEXPENSE**		

7.8 Modeling for SPI of the Sectors

7.8.1 Modeling the Field/Garden Sector

The SPI for Garden sector (SPIG), deals with the aspects of field activities undertaken by a garden. This indicator takes into account the expenses incurred in field activities and other attribute factors as illustrated earlier.

The causal mechanism of the factors of this sector is shown in the SD Cause & Effect diagram in Fig 7.9

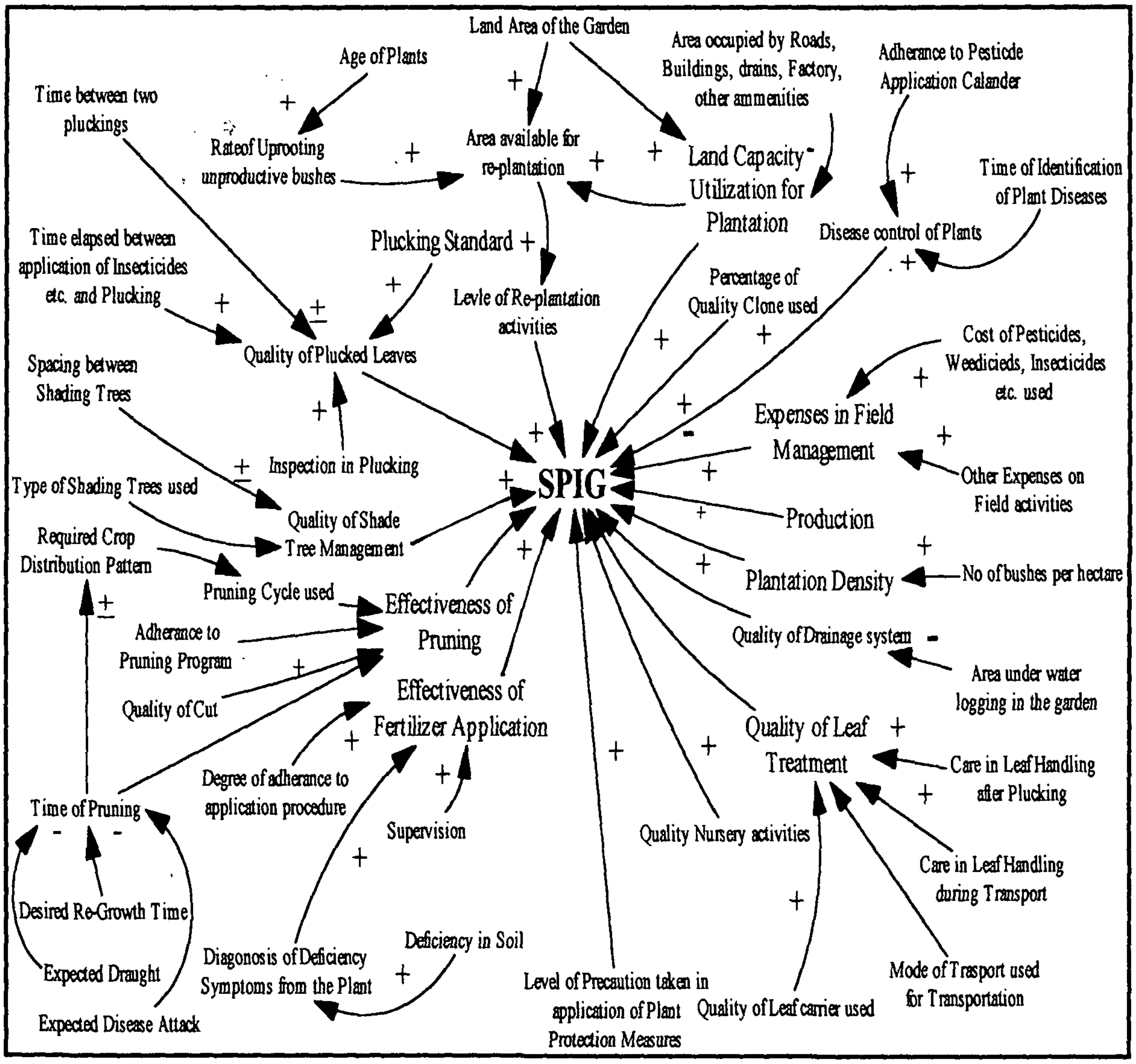


Fig7.9
Causal Mechanism of the Factors of Garden Sector

Table 7.2 and 7.3 show the variables and the attribute factors respectively in SPIG model

Table 7.2
Variables Used and their Descriptions in SPIG Model

Variable	Variable Name/ Description		Unit
EFERT	Cost of Fertilizer Used in the Computing Period		Rupees
EPP	Expenses Incurred in Plant Protection in the Computing Period		Rupees
EWEED	Cost of Weedicides Used in the Computing Period		Rupees
EPEST	Cost of Pesticides Used in the Computing Period		Rupees
ENUR	Expenses in Nursery Activities in the Computing Period		Rupees
EFIE	Other Expenses in Field Improvement in the Computing Period		Rupees
ERAE	Expenses Incurred in Field Rejuvenation Activities in the Computing Period		Rupees
TOTG	Total Expenses on Garden Sector in the Computing Period	EFERT + EPP+ EWEED + EPEST + ENUR + EFIE + ERAE	Rupees
RGETTE	Ratio of TOTG to TOTEXPENSE	TOTG / TOTEXPENSE	Unit less

Table 7.3
Attributes in the Performance Indicator for the Garden Sector (SPIG)

Notations (G_i)	Factors	Levels and Scores (Based on Standard Practice and/or Data) (G_iX_j)				Weightage (G_iW)
G_1	Ratio of Total Area of the Garden Under Tea to the Total Area of the Garden	Above 90% G_1X_1	80 – 90% G_1X_2	Below 80% G_1X_3		G_1W
G_2	Ratio of Area of Unutilized Land to the Total Area of the Garden	Below 0.5% G_2X_1	0.5 -1.0% G_2X_2	Above 1% G_2X_3		G_2W
G_3	Type of Plantation	Single Hedged G_3X_1	Double Hedged G_3X_2	Mixed G_3X_3		G_3W
G_4	Plant Population per Hectare	Above 18000 G_4X_1	16000-18000 G_4X_2	14000-16000 G_4X_3	Below 14000 G_4X_4	G_4W
G_5	Ratio of Number of Bushes Over 50 Years of Age to Total Number of Bushes	Over 75% G_5X_1	50% - 75% G_5X_2	25%- 50% G_5X_3	Below 25% G_5X_4	G_5W
G_6	Ratio of Number of Bushes from 35 to 50 years of Age to Total Number of Bushes	Over 75% G_6X_1	50%- 75% G_6X_2	25% - 50% G_6X_3	Below 25% G_6X_4	G_6W
G_7	Ratio of Number of Bushes from 10 to 35 years of Age to Total Number of Bushes	Over 75% G_7X_1	50%- 75% G_7X_2	25%-50% G_7X_3	Below 25% G_7X_4	G_7W

G_8	Ratio of Bushes of Age Less than 10 Years to Total Number of Bushes	Over 75% G_8X_1	50%- 75% G_8X_2	25%-50% G_8X_3	Below 25% G_8X_4		G_8W
G_9	Clones Used by the Garden	TRA Certified G_9X_1	Clones not certified by TRA G_9X_2				G_9W
G_{10}	Garden's Option for Clones (Refer Appendix IV-E)	Clones of Above Average Yield and Quality $G_{10}X_1$	Clones of High Quality and Average Yield $G_{10}X_2$	Clones of high Yield and Average Quality $G_{10}X_3$			$G_{10}W$
G_{11}	Ratio of Coarse to Total Plucking of the Garden in the Computing Period	Above 40% $G_{11}X_1$	20-40% $G_{11}X_2$	Below 20% $G_{11}X_3$			$G_{11}W$
G_{12}	Nursery Activities of the Garden	TRA Standardized $G_{12}X_1$	Not Standardized $G_{12}X_2$				$G_{12}W$
G_{13}	Frequency of Soil Testing for Primary and Secondary Deficiencies in Nutrients	Done before Plantation and Repeated Periodically $G_{13}X_1$	Done Before Plantation Only $G_{13}X_2$	No provision of Soil Testing $G_{13}X_3$			$G_{13}W$
G_{14}	Effect Analysis of Plant Rearing in Nursery (Appendix IV-F)	Done by Cause and effect analysis $G_{14}X_1$	Not Analyzed $G_{14}X_2$				$G_{14}W$
G_{15}	Determination of Spacing in Plantation	Determined on the Basis of Bush Character and Soil Condition $G_{15}X_1$	Traditionally or Arbitrary Determined $G_{15}X_2$				$G_{15}W$
G_{16}	In Single Hedge Plantation, Spacing Maintained is Nearly Equal to (cm) (Refer Appendix IV-I)	90 x 60 $G_{16}X_1$	100 x 60 $G_{16}X_2$	105 x 60 $G_{16}X_3$	105 x 65 $G_{16}X_4$	105 x 75 $G_{16}X_5$	$G_{16}W$*
G_{17}	In Double Hedge Plantation, Spacing Maintained is Nearly Equal to (cm) (Refer Appendix IV-I)	105 x 70 x 75 $G_{17}X_1$	110 x 70 x 70 $G_{17}X_2$	110x 75x 75 $G_{17}X_3$	110 x 70 x 65 $G_{17}X_4$	110 x 70 x 60 $G_{17}X_5$	$G_{17}W$**
G_{18}	Techniques used for Weed control	Hand Weeding $G_{18}X_1$	Hand Weeding for Collar Region with Herbicides for Remainder $G_{18}X_2$				$G_{18}W$
G_{19}	Frequency of Inspection for Mites Attack, Insect Damage, Diseases for Young Bushes	Weekly $G_{19}X_1$	Fortnightly $G_{19}X_2$	Monthly $G_{19}X_3$	Bi-monthly $G_{19}X_4$		$G_{19}W$
G_{20}	Basis of Assessment of Prune Parameters	Thorough 100% Inspection of the Garden $G_{20}X_1$	Sampling Inspection for Assessment $G_{20}X_2$	Not Assessed, Traditional $G_{20}X_3$			$G_{20}W$
G_{21}	Policy on Bed of Prune	Always parallel to Ground, No Deviation Allowed $G_{21}X_1$	Roughness in the Bed Allowed $G_{21}X_2$				$G_{21}W$
G_{22}	P and K is Regulation in Pruning	Every Time, After Assessing the Soil Condition $G_{22}X_1$	Occasional $G_{22}X_2$	Not Regulated $G_{22}X_3$			$G_{22}W$

G_{23}	Pruning Cycle Adopted by the Garden	3 Years Cycle $G_{23}X_1$	4 Years Cycle $G_{23}X_2$			$G_{23}W$
G_{24}	Normal Period of Pruning for Matured Tea Adopted by the Garden	December to Mid January $G_{24}X_1$	Any Other Convenient Time for the Garden $G_{24}X_2$			$G_{24}W$
G_{25}	Normal Period of Pruning Young Tea Adopted by the Garden	End January to Early February $G_{25}X_1$	Any Other Convenient Time for the Garden $G_{25}X_2$			$G_{25}W$
G_{26}	Basis of Adoption of Pruning Cycle of the Garden	Research Based $G_{26}X_1$	Experienced Based $G_{26}X_2$	Traditional $G_{26}X_3$		$G_{26}W$
G_{27}	Plucking Standard Followed by the Garden	Fine Plucking $G_{27}X_1$	Coarse Plucking $G_{27}X_3$			$G_{27}W$
G_{28}	Size of the Leaf Carrying Basket Used by the Pluckers	Standardized by TRA (55 x 55 x 55) cm $G_{28}X_1$	Standard Baskets not Used $G_{28}X_2$			$G_{28}W$
G_{29}	Maximum Capacity of the Basket	Below 10 kg $G_{29}X_1$	10 - 15 Kg $G_{29}X_2$	15- 20 Kg $G_{29}X_3$	More than 20Kg $G_{29}X_4$	$G_{29}W$
G_{30}	The Designed Capacity of Leaf Carrying Frame	Below 100 Kg $G_{30}X_1$	100 -120 kg $G_{30}X_2$	120 - 140 kg $G_{30}X_3$	More than 140 kg $G_{30}X_4$	$G_{30}W$
G_{31}	Level of Care Taken Against Tight Packing of the Leaves in the Basket	High Care Under Strict Supervision $G_{31}X_1$	Occasionally when Quality Tea Required $G_{31}X_2$	Never Stressed $G_{31}X_3$		$G_{31}W$
G_{32}	Inspection of Plucked Leaves for Contamination with Sand and Soil	Always Done $G_{32}X_1$	Occasionally Done $G_{32}X_2$	No Inspection for Contamination $G_{32}X_3$		$G_{32}W$
G_{33}	Average Time Between Plucking and Withering	< 14 Hours $G_{33}X_1$	14-20 Hours $G_{33}X_2$	>20 Hours $G_{33}X_3$	Arbitrary $G_{33}X_4$	$G_{33}W$
G_{34}	Basis of Selection of Temporary, Semi-Permanent, and Permanent Shading Trees in the Garden (Refer Appendix IV-G)	TRA Standardized Trees $G_{34}X_1$	Arbitrary, Not Standardized Trees $G_{34}X_2$			$G_{34}W$
G_{35}	Basis of Spacing Between the Shading Trees (Refer Appendix IV-G)	TRA Standardized $G_{35}X_1$	Arbitrary, Not Standardized $G_{35}X_2$			$G_{35}W$
G_{36}	Disease Control Programme of the Garden	Includes the Shade Trees Also $G_{36}X_1$	Does not Include the Shade Trees $G_{36}X_2$			$G_{36}W$
G_{37}	Record of Pest Application	Stressed a Lot and Referred Before Next Application $G_{37}X_1$	Not Stressed Much and Not Referred Before Next Application $G_{37}X_2$			$G_{37}W$
G_{38}	Grade and Quantity of Fertilizers used by the Garden	As Per Recommendation of TRA $G_{38}X_1$	As Per Experience of the Garden $G_{39}X_2$			$G_{38}W$
G_{39}	Weed Control Outside the Tea Area	Done Periodically and is Considered As an Important Activity of the Garden $G_{39}X_1$	Not Undertaken Periodically : Least Stressed $G_{39}X_2$			$G_{39}W$

G_{40}	Use of Protective Clothing in Pest Application	Consistent, Used in Every Application $G_{40}X_1$	Not Consistent $G_{40}X_2$			$G_{40}W$
G_{41}	Measures for Fungus Attack of the Bushes (Refer Appendix IV-L)	Done as per Recommendation of TRA $G_{41}X_1$	Done arbitrarily $G_{41}X_2$			$G_{41}W$
G_{42}	Inspection for Over and Under Spraying of Pesticides	Done After Each Application $G_{42}X_1$	Not Done Every Time $G_{42}X_2$	Not Done At All $G_{42}X_3$		$G_{42}W$
G_{43}	Basis of Uprooting Programme of Bushes	Survey of Yield $G_{43}X_1$	Survey of Vacancy $G_{43}X_2$	Survey of both Yield and Vacancy $G_{43}X_3$	Survey of Quality $G_{43}X_4$	$G_{43}W$
G_{44}	Basis of Priority in Uprooting	Sections Yielding < 65% of the Production $G_{44}X_1$	Sections > 25 % Vacancy $G_{44}X_2$	Sections Yielding Low Quality Tea $G_{44}X_3$	Arbitrary $G_{44}X_4$	$G_{44}W$
G_{45}	Existence of Estate Rejuvenation Calendar (Refer Appendix IV-K)	Exists and Result oriented $G_{45}X_1$	Exists but Result not Assessed $G_{45}X_2$	Does not Exist $G_{45}X_3$		$G_{45}W$
G_{46}	Basis of Selection of Rejuvenation Activities	Tea with Poor Frames $G_{46}X_1$	Tea with Poor Frames and Good Collar $G_{46}X_2$	Arbitrary $G_{46}X_3$		$G_{46}W$
G_{47}	The Pattern of Yield for Last Five Years of the Garden	Increasing Trend $G_{47}X_1$	Constant Trend $G_{47}X_2$	Decreasing Trend $G_{47}X_3$		$G_{47}W$
G_{48}	Type of Manure Used	Organic $G_{48}X_1$	Inorganic $G_{48}X_2$			$G_{48}W$
G_{49}	Pesticides, Weedicides, Manure Testing for Assessing Ingredients	Tested by Qualified Tester After each Purchase Before Application $G_{49}X_1$	Tested by Qualified Tester Once in a Season $G_{49}X_2$	No Testing Done $G_{49}X_3$		$G_{49}W$
G_{50}	pH of Soil (Before Treatment)	Below 4.5 $G_{50}X_1$	4.5- 5.5 $G_{50}X_2$	Above 5.5 $G_{50}X_3$		$G_{50}W$
G_{51}	Pre-Treated Soil Bulk Density (g/cc)	<1.20 $G_{51}X_1$	1.21-1.40 $G_{51}X_2$	1.41-1.60 $G_{51}X_3$	1.61-1.70 $G_{51}X_4$	$G_{51}W$

*** If the garden has only double-hedged plantation, $G_{16}W = 0$**
**** If the garden has only single-hedged plantation, $G_{17}W = 0$**

7.8.1.1 Computation of SPIG

The Sector Performance Indicator of the Garden Sector is a function of the variable RGETTE (Ratio of Total Expenses on Garden Sector in the Computing Period to Total Expenses Incurred by the Garden in the Period), PPH (Production per Unit Area), and algebraic sum of the product of scores and weightages of all the attribute factors considered.

Thus, if

$$GA = \sum ((G_i X_j) \times (G_i W)$$

i (factors)= 1 to 51 and j(option selected) = 1/2/3/4/5

then

SPIG = f (RGETTE, PPH, GA)............. (7.2)

The Sect oral Performance Indicator for the Garden Sector is given by:

SPIG = [W_{RGETTE} x Preference Value (RGETTE) + W_{PPH} x Preference Value (PPH)] x W_{GV} + Preference Value (GA) x W_{GA} ....(7.3)

where

W_{RGETTE} & W_{PPH} are the weightages assigned to RGETTE and PPH respectively

$$(W_{RGETTE} + W_{PPH} = 1)$$

and W_{GV} & W_{GA} are the weightages assigned to the variables and attributes of the Garden Sector respectively

$$(W_{GV} + W_{GA} = 1)$$

The controlling equation for the Preference Value of RGETTE (Scale 0-10):

Allotted maximum = $RGETTE_{MAX}$

Allotted minimum = $RGETTE_{MIN}$

Preference Equation = $C_{GV} \log_{10} (RGETTE_i / RGETTE_{MAX})$.......... (7.4)

Where C_{GV} is a constant to be found out by assigning $RGETTE_{MAX}$ & $RGETTE_{MIN}$

The controlling equation for the Preference Value of PPH (Scale 0- 10)

Allotted Maximum = PPH_{MAX}

Allotted Minimum = PPH_{MIN}

Preference Equation = $C_{PPH} \log_{10} (PPH_i / PPH_{MIN})$ .... (7.5)

Where C_{PPH} is a constant to be found out by assigning $(PPH)_{MAX}$ & PPH_{MIN}

The controlling equation for the Preference Value of GA (Scale 0- 10)

Maximum = GA_{MAX} & Minimum = GA_{MIN}

Preference Equation = $C_{GA} \log_{10} (GA_i / GA_{MIN})$ .... (7.6)

Where C_{GA} is a constant to be found out by assigning GA_{MAX} & GA_{MIN}

7.8.2 Modeling the Processing Sector

The SPI for Processing sector (SPIPROC) deals with the aspects of processing of tea inside the factory. This indicator takes into account the cost of machines and Equipment involved in production and other attribute factors as illustrated in the previous sections. The causal mechanism of the factors of this sector is shown in the SD Cause & Effect diagram in Fig 7.10

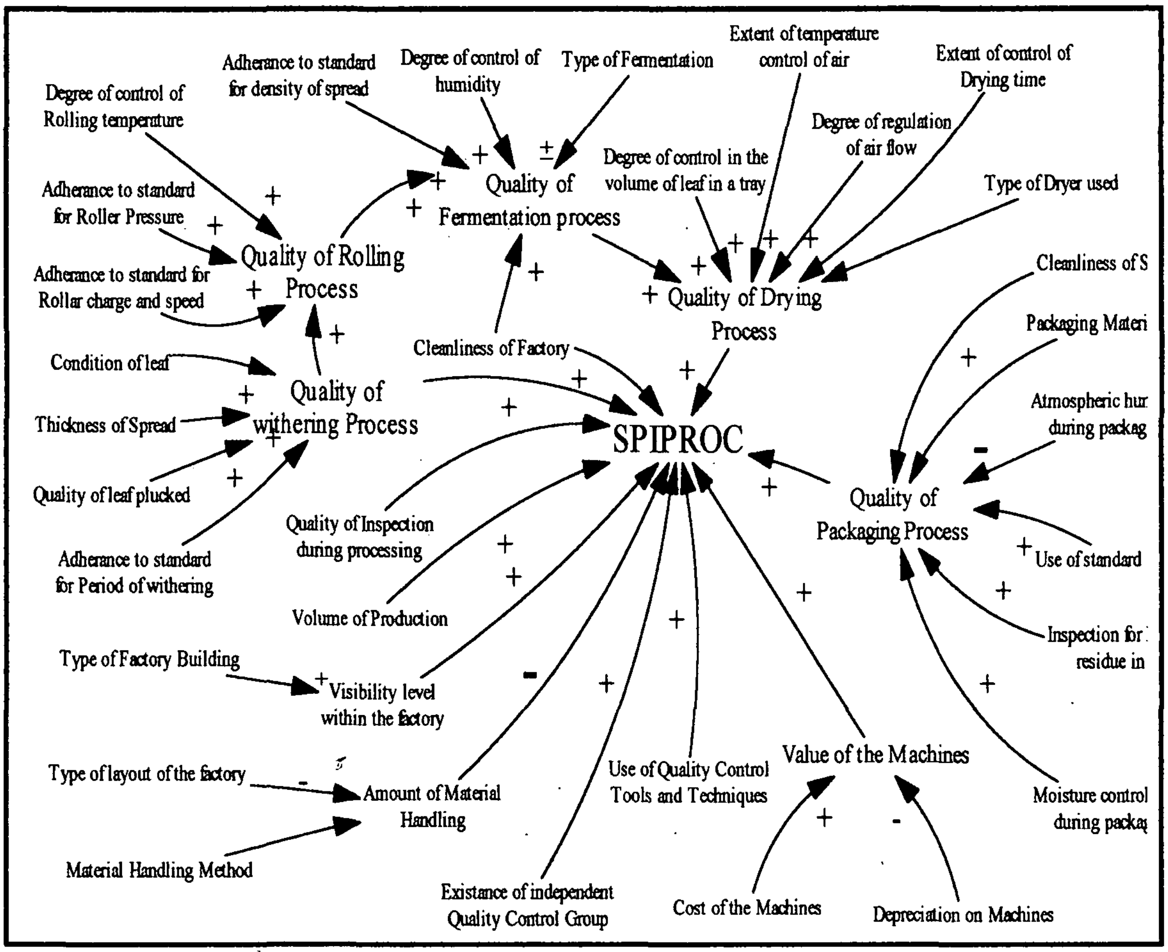


Fig. 7.10
Causal Mechanism of the Factors of Processing Sector

The variables and attribute factors in SPIPROC model are given in Table 7.4 and 7.5 respectively.

Table 7.4
Variables Used and Their Descriptions in SPIPROC Model

Variable	Variable Factor Description		Unit
AGLI	Total Green Leaf Plucked during the Computing Period		Kg
ADM	Average Quantity of all Type of Tea in the Dry Mouth.	= CTC + ORTHODOX = PDN	Kg
RCON	Leaf to Made Tea Conversion Ratio	= ALGI / PDN	Unit less

Table 7.5
Attributes in the Performance Indicator for the Processing Sector (SPIPROC)

Notations (PR_i)	Factors	Levels and Scores (Based on Standard Practice and/or Data) (PR_iX_j)			Weightage (PR_iW)
PR_1	Calibration of Measuring Equipment Used in the Factory	Calibrated Periodically PR_1X_1	Not Calibrated Periodically PR_1X_2		PR_1W
PR_2	Inspection to Assess Leaf Damage Before Withering	Inspected Every time PR_2X_1	Inspected When Quality Tea Required PR_2X_2	Not Inspected At All PR_2X_3	PR_2W
PR_3	Cleaning of Withering Trough Before Placing the Green Leaves on it	Cleaned Thoroughly Every Time PR_3X_1	Cleaned Thoroughly but Sometimes Ignored PR_3X_2	Periodical Cleaning is Done Only PR_3X_3	PR_3W
PR_4	Thickness of Spread in Withering Trough	Standardized PR_4X_1	Not Standardized, Arbitrary PR_4X_2		PR_4W
PR_5	Normal Period of Withering	<12 hours PR_5X_1	> 12 but < 16 hours PR_5X_2	> 16 hours PR_5X_3	PR_5W
PR_6	Consistency in Maintaining the Period of Withering	Very Much consistent PR_6X_1	Variation Exists PR_6X_2		PR_6W
PR_7	Adoption Of Humidity Control Measures In Withering	Adopted PR_7X_1	Not adopted PR_7X_2		PR_7W
PR_8	Targeted Temperature of Hot Air Maintained during Withering	<30° C PR_8X_1	> 30° C PR_8X_2	Not Measured At All PR_8X_3	PR_8W
PR_9	Inspection Of Withered Leaf For Assessment of Withering before Putting to Rolling Operation	Rigorous Inspection, every time PR_9X_1	Occasional Inspection PR_9X_2	No Inspection PR_9X_3	PR_9W
PR_{10}	Mode of Transport of Withered Leaf to the Rolling Machine	Manual $PR_{10}X_1$	Conveyor $PR_{10}X_2$		$PR_{10}W$
PR_{11}	Level of Care Taken Against Leaf Rupture in Transportation from Withering Trough to Rolling Table	High Care, Occasionally When Quality Tea Required $PR_{11}X_1$	Very High Care, Always $PR_{11}X_2$	Inconsistent/ No Proper Care Taken $PR_{11}X_3$	$PR_{11}W$
PR_{12}	Cleaning of CTC/Rolling Machines before Putting the Withered Leaves	Cleaned Thoroughly Every Time $PR_{12}X_1$	Periodical Cleaning $PR_{12}X_2$		$PR_{12}W$
PR_{13}	Assessment Of "Degree Of Wither"	Properly Assessed and is Used as an input to Decide the Rolling Parameters $PR_{13}X_1$	Not Assessed/ Not Properly Assessed $PR_{13}X_2$		$PR_{13}W$
PR_{14}	Provision for Continuous Monitoring of Rolling Pressure	Exists and Continuously Monitored Every Time $PR_{14}X_1$	Exists But No Continuous Monitoring Every Time $PR_{14}X_2$	No Provision of Monitoring $PR_{14}X_3$	$PR_{14}W$

PR_{15}	Provision for Continuous Monitoring of Rolling Temperature	Exists And Continuously Monitored Every Time $PR_{15}X_1$	Exists But No Continuous Monitoring Every Time $PR_{15}X_2$	No Provision of Monitoring $PR_{15}X_3$	$PR_{15}W$
PR_{16}	The CTC Cutter Tooth	Standardized $PR_{16}X_1$	Not Standardized $PR_{16}X_2$		$PR_{16}W$
PR_{17}	Humidity Control Measure in the Rolling Process	Exists $PR_{17}X_1$	No Provision $PR_{17}X_2$		$PR_{17}W$
PR_{18}	Inspection for Bacteria Attack in Rolled Tea	Done Every Time $PR_{18}X_1$	Occasionally Done $PR_{18}X_2$	Not Done At All $PR_{18}X_3$	$PR_{18}W$
PR_{19}	Assessment of Rolling	Assessed Every Time $PR_{19}X_1$	Assessed Occasionally $PR_{19}X_2$	Not Assessed At All $PR_{19}X_3$	$PR_{19}W$
PR_{20}	Type of Fermentation Used	Floor $PR_{20}X_1$	Floor and Rack $PR_{20}X_2$	Continuous Fermenting Machines $PR_{20}X_3$	$PR_{20}W$
PR_{21}	Cleanliness of Fermenting Floors/Troughs/Machines	Cleaned Thoroughly Every Time $PR_{21}X_1$	Cleaned Periodically $PR_{21}X_2$	Not Stressed Much $PR_{21}X_3$	$PR_{21}W$
PR_{22}	Testing of Floors etc. before Fermenting for Bacteria Formation	Done every Time $PR_{22}X_1$	Done Occasionally $PR_{22}X_2$	Not Done At All $PR_{22}X_3$	$PR_{22}W$
PR_{23}	Thickness of Spread in Fermentation	Standardized and Monitored $PR_{23}X_1$	Standardized but Occasional Monitoring $PR_{23}X_2$	Not Standardized/ Traditional $PR_{23}X_3$	$PR_{23}W$
PR_{24}	Humidity Control Measures in Fermentation	Exists $PR_{24}X_1$	Exists, No Monitoring $PR_{24}X_2$	No Humidity Control Measure $PR_{24}X_3$	$PR_{24}W$
PR_{25}	Fermentation Temperature	Standardized $PR_{25}X_1$	Not Standardized $PR_{25}X_3$		$PR_{25}W$
PR_{26}	Fermenting Time is Standardized as per the Type of Leaf	Yes $PR_{26}X_1$	No $PR_{26}X_2$		$PR_{26}W$
PR_{27}	Ventilation of Fermenting Roll	Well Ventilated $PR_{27}X_1$	Poor Ventilation $PR_{27}X_2$		$PR_{27}W$
PR_{28}	Assessment of Fermentation	Using Visual Assessment and Nose Test $PR_{28}X_1$	Using Colour Sensors $PR_{28}X_2$		$PR_{28}W$
PR_{29}	Test of Tea Leaves after Fermentation for Detection of Contamination	Done $PR_{29}X_1$	Not Done $PR_{29}X_2$		$PR_{29}W$
PR_{30}	Cleaning of Drying Trays Before Drying Process	Cleaned Thoroughly Every Time $PR_{30}X_1$	Cleaned Periodically $PR_{30}X_2$		$PR_{30}W$
PR_{31}	Type of Dryer Used for Production of Major Portion Total Production of Tea	ECP $PR_{31}X_1$	FBD $PR_{31}X_2$	VFBD $PR_{31}X_3$	$PR_{31}W$
PR_{32}	Monitoring of Drying Temperature	Constantly Monitored $PR_{32}X_1$	Casually Monitored $PR_{32}X_2$		$PR_{32}W$

PR_{33}	Thickness of Spread in the Drying Trays	Standardized, Followed Strictly $PR_{33}X_1$	Standardized, Not Followed Every Time $PR_{33}X_2$	Not Standardized $PR_{33}X_3$	$PR_{33}W$
PR_{34}	Standard for Thickness of Spread for Different Air Flow Rate and Size of Leaves	Spread of Thickness Varies Accordingly $PR_{34}X_1$	Thickness of Spread Not A Function of These Parameters $PR_{34}X_2$		$PR_{34}W$
PR_{35}	Assessment of Case Hardening and Wetness of Dried Tea	Done Every Time on Sampling Basis $PR_{35}X_1$	Not Assessed/ Occasional Assessment $PR_{35}X_2$		$PR_{35}W$
PR_{36}	Assessment of Moisture Content in Dried Tea	Done Every Time $PR_{36}X_1$	Occasionally Done $PR_{36}X_2$	No Provision of Such Assessment $PR_{36}X_3$	$PR_{36}W$
PR_{37}	Type of Fibre Extraction	Manual $PR_{37}X_1$	Using Magnetic Separator $PR_{37}X_2$		$PR_{37}W$
PR_{38}	Cleaning of Sieves For Sorting	Done Every Time $PR_{38}X_1$	Done Periodically $PR_{38}X_2$		$PR_{38}W$
PR_{39}	Inspection of Sieves and Periodic Replacement	Inspected Periodically and Replaced $PR_{39}X_1$	Breakdown Replacement $PR_{39}X_2$		$PR_{39}W$
PR_{40}	Size of Sieves	Standard Size $PR_{40}X_1$	Size deviates from standard $PR_{40}X_2$		$PR_{40}W$
PR_{41}	Inspection Of Sieves For Corrosion, Bacteria Formation And Presence Of Foreign Materials	Inspected Regularly $PR_{41}X_1$	Not stressed $PR_{41}X_2$		$PR_{41}W$
PR_{42}	Inspection of Tea before Packaging for Presence of Harmful Residual Insecticides etc.	Inspected Every Time $PR_{42}X_1$	Inspected Occasionally $PR_{42}X_2$	Not Inspected At All $PR_{42}X_3$	$PR_{42}W$
PR_{43}	Use of Standard Packaging Materials	TRA Standardized Packaging Material Used $PR_{43}X_1$	Packaging Material not Standardized $PR_{43}X_2$		$PR_{43}W$
PR_{44}	Inspection to Prevent Mixing of two Grades	Monitored Constantly $PR_{44}X_1$	Occasionally Monitored $PR_{44}X_2$		$PR_{44}W$
PR_{45}	Environment of the Packaging Room	Kept Dust Free Always $PR_{45}X_1$	No/Least Effort for Protection from Dust $PR_{45}X_2$		$PR_{45}W$
PR_{46}	Mode of Keeping the Unpackaged Tea	Kept Openly $PR_{46}X_1$	Stored in Closed Container $PR_{46}X_2$		$PR_{46}W$
PR_{47}	Cleanliness of Workers Engaged in Packaging	High Attention for Worker Cleanliness $PR_{47}X_1$	No/Least Attention for Worker Cleanliness $PR_{47}X_2$		$PR_{47}W$
PR_{48}	Level of Organized Effort put to Identify the "Points of Wastes" in Processing	High $PR_{48}X_1$	Low $PR_{48}X_2$	Very Low $PR_{48}X_3$	$PR_{48}W$
PR_{49}	Capacity Utilization of Machines	High Utilization $PR_{49}X_1$	Low Utilization $PR_{49}X_2$		$PR_{49}W$
PR_{50}	Existence of Points of Congestion (Bottlenecks) in Processing	Flow of In-Process Tea is not Smooth, Point(s)	Smooth Flow of In-Process Tea		$PR_{50}W$

		of Congestion Exists $PR_{50}X_1$	$PR_{50}X_2$	
PR_{51}	Packaging Inspected For Air Tightness	Strict Inspection $PR_{51}X_1$	Not/Least stressed $PR_{51}X_2$	$PR_{51}W$
PR_{52}	Layout of the Factory	Good, Low Cost of Material Handling $PR_{52}X_1$	Poor, High Cost of Material Handling $PR_{52}X_2$	$PR_{52}W$
PR_{53}	Design of Factory Building and Roofing	Adequate Light Inside $PR_{53}X_1$	Inadequate Light $PR_{53}X_2$	$PR_{53}W$
PR_{54}	Rest Room in The Factory	Exists $PR_{54}X_1$	No Such Separate Room $PR_{54}X_2$	$PR_{54}W$
PR_{55}	Drinking Water, Lavatory Facility within the Factory	Satisfactory $PR_{55}X_1$	Not Satisfactory $PR_{55}X_2$	$PR_{55}W$
PR_{56}	Emergency Care Facility within the Factory	Satisfactory $PR_{56}X_1$	Not Satisfactory $PR_{56}X_2$	$PR_{56}W$
PR_{57}	Canteen Facility within the Factory	Exists $PR_{57}X_1$	No such Facility $PR_{57}X_2$	$PR_{57}W$

7.8.2.1 Computation of SPIPROC

The Sector Performance Indicator of the Production Sector is a function of the variable RCON and algebraic sum of the product of scores and weightages of all the attribute factors considered.

Thus, if

$$PRA = \Sigma\,((PR_i X_j) \times (PR_i W))$$

i (factors)= 1 to 57 and j(option selected) = 1/2/3

then

SPIPROC = f (RCON, PRA)................ (7.7)

The Sect oral Performance Indicator for the Processing Sector is given by:

$SPIPROC = W_{PRV}$ x Preference Value (RCON) + W_{PRA} x Preference Value (PRA)..............(7.8)

where W_{PRV} & W_{PRA} are the weightages assigned to the variables and attributes of the *Processing Sector respectively.*

$$(W_{PRV} + W_{PRA} = 1)$$

The controlling equation for the Preference Value of RCON (Scale 0-10):

Allotted maximum = $RCON_{MAX}$

Allotted minimum = $RCON_{MIN}$

Preference Equation = $C_{PRV} \log_{10} (RCON_i / RCON_{MIN})$..... (7.9)

Where C_{PRV} is a constant to be found out by assigning $RCON_{MAX}$ and $RCON_{MIN}$

The controlling equation for the Preference Value of PRA (Scale 0- 10)

Maximum = PRA_{MAX}

Minimum = PRA_{MIN}

Preference Equation = $C_{PRA} \log_{10} (PRA_i / PRA_{MIN})$.......... (7.10)

Where C_{PRA} is a constant to be found out by assigning PRA_{MAX} and PRA_{MIN}

7.8.3 Modeling the Energy Sector

The SPI for Energy sector (SPIENG) deals with the aspects of energy consumption and activities undertaken by a garden for optimizing the estate energy consumption. This indicator takes into account the expenses incurred in energy consumed in all forms and other attribute factors as illustrated in Chapter VII. The causal mechanism of the factors of the Energy Sector is shown in the SD Cause & Effect diagram in Fig 7.11

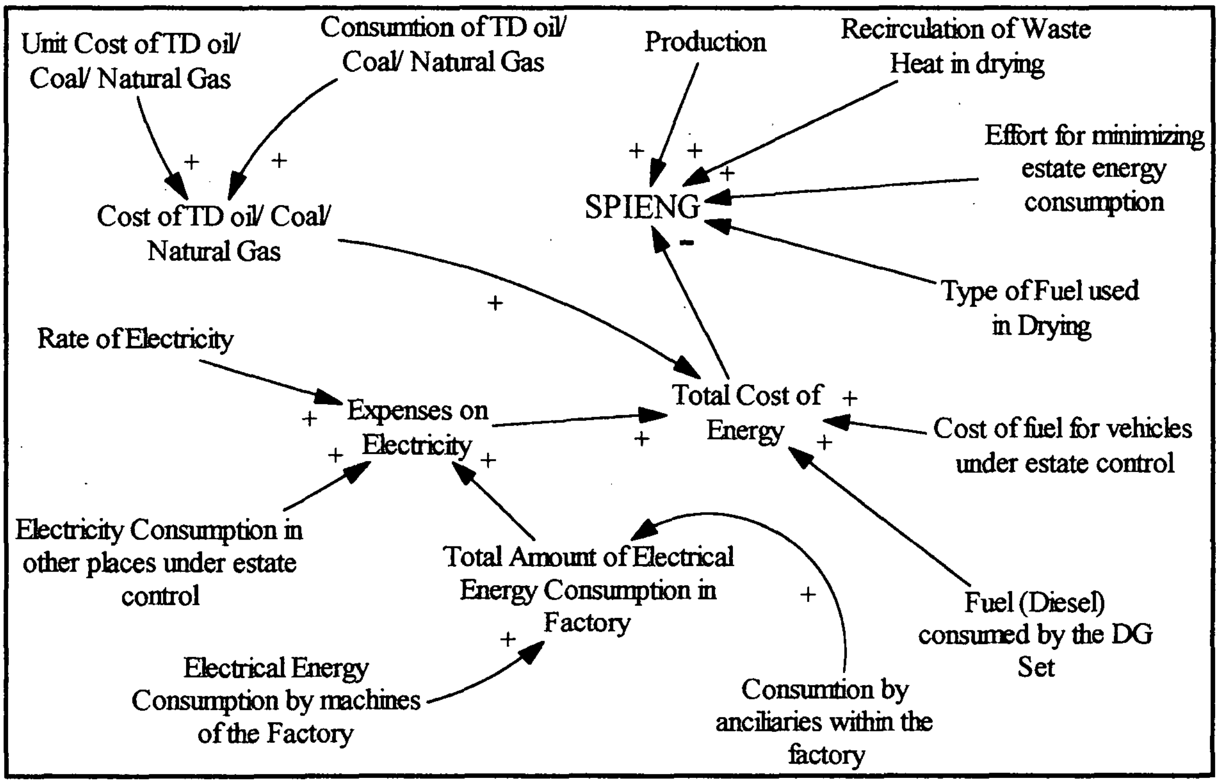


Fig. 7.11
Causal Mechanism of the Factors of Energy Sector

The variables and attribute factors in SPIPENG model are given in Table 7.6 and 7.7 respectively.

Table 7.6
Variables Used and their Descriptions in SPIENG Model

Variable	Variable Name/ Description		Unit
EEF	Total Expenses on Electrical Energy in Factory for the Computing Period		Rupees
EEB	Total Expenses on Electrical Energy in Bunglows for the Computing Period		Rupees
EESL	Total Expenses of Electrical Energy in Street Lighting for the Computing Period		Rupees
EEOP	Total Expenses of Electrical Energy in other Places of Estate Control for the Computing Period		Rupees
FEVE	Expenses on Fuel of the Vehicles under Estate Control for the Computing Period		Rupees
FEDG	Total Expenses of Fuel for the Auxiliary Power Supply (DG set/ Turbine) for the Computing Period		Rupees
FED	Total Expenses of Fuel for the Dryer for the Computing Period		Rupees
TOTEE	Total Expenses on Electrical Energy for the Computing Period	EEF + EEB + EESL + EEOP	Rupees
TOTF	Total Expenses on Fuel for the Computing Period	FEVE + FEDG + FED	Rupees
TOTENG	Total Expenses on Energy Sector for the Computing Period	TOTEE + TOTF	Rupees
ETP	Energy Consumption per Kg of Tea Production	TOTENG / PDN	Rupees/Kg

Table 7.7
Attributes in the Performance Indicator for the Energy Sector (SPIENG)

Notations (ENG_i)	Factors	Levels and Scores (Based on Standard Practice and/or Data) (ENG_iX_j)					Weightage (ENG_iW)
ENG_1	Average Power Cut per Day in the Garden	> 8 Hours ENG_1X_1	4-8 Hours ENG_1X_2	2- 4 Hours ENG_1X_3	< 2 Hours ENG_1X_4	Captive Generation ENG_1X_5	ENG_1W
ENG_2	Source of Primary Electrical Power	ASEB* Power Supply ENG_2X_1			Captive Generation ENG_2X_2		ENG_2W
ENG_3	Source of Secondary (Stand-by) Power Supply	DG Set ENG_3X_1		Gas Turbine ENG_3X_2		No Source of Secondary Power ENG_3X_3	ENG_3W
ENG_4	Fuel for Dryer	TD Oil ENG_4X_1		Natural Gas ENG_4X_2		Coal ENG_4X_3	ENG_4W

ENG_5	Secondary Power Supply of the Garden Covers	Whole Garden ENG_5X_1	Factory only ENG_5X_2	Factory +Essential Infra-structures ENG_5X_3	No Source of Secondary Power ENG_5X_4		ENG_5W
ENG_6	Re-circulation of Exhaust Thermal Energy of Drying	Re-Circulated ENG_6X_1	Allowed to Escape to Atmosphere ENG_6X_2				ENG_6W
ENG_7	Stability of Voltage of Primary Power Supply	Very Stable (within 2%) ENG_7X_1	Stable (2-5%) ENG_7X_2	Unstable (> 5%) ENG_7X_3			ENG_7W
ENG_8	Ratio of Electrical Energy Consumption in Withering to Total Energy	20 - 25% ENG_8X_1	25 - 30% ENG_8X_2	> 30 % ENG_8X_3			ENG_8W
ENG_9	Ratio of Electrical Energy Consumption in Rolling/CTC to Total Energy	30-35% ENG_9X_1	35 - 40% ENG_9X_2	>40% ENG_9X_3			ENG_9W
ENG_{10}	Ratio of Electrical Energy Consumption in Fermentation to Total Energy	0 - 5 % $ENG_{10}X_1$	5 - 10% $ENG_{10}X_2$	>10% $ENG_{10}X_3$			$ENG_{10}W$
ENG_{11}	Ratio of Electrical Energy Consumption in Drying to Total Energy	20 - 25% $ENG_{11}X_1$	25 - 30% $ENG_{11}X_2$	> 30 % $ENG_{11}X_3$			$ENG_{11}W$
ENG_{12}	Ratio of Electrical Energy Consumption in Grading and Sorting to Total Energy	0 - 5% $ENG_{12}X_1$	5 - 10% $ENG_{12}X_2$	> 10% $ENG_{12}X_3$			$ENG_{12}W$
ENG_{13}	Ratio of Total Electrical to Thermal Energy in Processing	10 - 15% $ENG_{13}X_1$	15 - 20% $ENG_{13}X_2$	> 20% $ENG_{13}X_3$			$ENG_{13}W$
ENG_{14}	Total Electrical + Thermal Energy Consumption per Kg of Made Tea	3-4 KWH $ENG_{14}X_1$	4-5 KWH $ENG_{14}X_2$	> 5 KWH $ENG_{14}X_3$			$ENG_{14}W$
ENG_{15}	Average life of Electrical Equipment in the Factory	New $ENG_{15}X_1$	Old (>15 years) $ENG_{15}X_2$	Very Old (>25 years) $ENG_{15}X_3$			$ENG_{15}W$
ENG_{16}	Ratio of Ex-Factory (Under Estate Control)Electrical Energy Consumption to Total Energy	> 40% $ENG_{16}X_1$	30-40% $ENG_{16}X_2$	20-30% $ENG_{16}X_3$	10 - 20% $ENG_{16}X_4$	< 10 % $ENG_{16}X_5$	$ENG_{16}W$
ENG_{17}	Capacity Utilization of the Machineries within the Factory	Operates at Highest Efficiency Most of the Time $ENG_{17}X_1$	Operates below Highest Efficiency Most of the Time $ENG_{17}X_2$				$ENG_{17}W$
ENG_{18}	Production Loss for Mal-Functioning of Electrical Equipment	Frequently $ENG_{18}X_1$	Rarely $ENG_{18}X_2$				$ENG_{18}W$
ENG_{19}	% of Unusable Electrical Equipment (Fans, Motors etc. in the Factory)	> 25 % $ENG_{19}X_1$	15- 25 % $ENG_{19}X_2$	< 15 % $ENG_{19}X_3$	0 % $ENG_{19}X_4$		$ENG_{19}W$

ENG_{20}	Status of Auxiliary (Supporting) Electrical Equipment in the Factory	Excellent $ENG_{20}X_1$	Good $ENG_{20}X_2$	Poor $ENG_{20}X_3$	$ENG_{20}W$
ENG_{21}	Mode of Storing Solid Fuels	Protected from Rain and Environmental Moisture $ENG_{21}X_1$	Kept Openly (No/Least Care Taken) $ENG_{21}X_2$		$ENG_{21}W$**
ENG_{22}	Number of Electrical Equipment Consuming More than Rated	Many $ENG_{22}X_1$	A Few $ENG_{22}X_2$	None $ENG_{22}X_3$	$ENG_{22}W$
ENG_{23}	Electrical Power Theft from the Estate Cable Lay-out	A lot $ENG_{23}X_1$	A Few $ENG_{23}X_2$	None $ENG_{23}X_3$	$ENG_{23}W$
ENG_{24}	Calibration of Thermometers Used in Dryers	Calibrated Periodically $ENG_{24}X_1$	Not Calibrated Periodically $ENG_{24}X_2$		$ENG_{24}W$
ENG_{25}	Condition of House-Hold Cables and Inter-connections	Satisfactory $ENG_{25}X_1$	Not Satisfactory $ENG_{25}X_2$		$ENG_{25}W$
ENG_{26}	Number of Vehicles Under Estate Control	Redundant $ENG_{26}X_1$	Optimum $ENG_{26}X_2$	Deficient $ENG_{26}X_3$	$ENG_{26}W$
ENG_{27}	Record Sheet for Each Dryer to Ascertain Specific Fuel Consumption	Exists $ENG_{27}X_1$	No Record Keeping on this Aspect $ENG_{27}X_2$		$ENG_{27}W$
ENG_{28}	Energy Audit	Done Regularly $ENG_{28}X_1$	Not Done Regularly $ENG_{28}X_2$		$ENG_{28}W$
ENG_{29}	Competency of Garden Electrician	Skilled $ENG_{29}X_1$	Not skilled $ENG_{29}X_2$		$ENG_{29}W$
ENG_{30}	Equipment Modernization Programme of the Garden	Undertaken Frequently $ENG_{30}X_1$	Rarely Undertaken/ Not Undertaken $ENG_{30}X_2$		$ENG_{30}W$
ENG_{31}	Inspection for Malfunctioning of Electrical Equipment and Burner of Dryer	Frequent Inspection $ENG_{31}X_1$	Only in Overhauling Period $ENG_{31}X_2$		$ENG_{31}W$
ENG_{32}	Level of Management's Effort to Optimize Power Consumption	Encouraging $ENG_{32}X_1$	Discouraging $ENG_{32}X_2$		$ENG_{32}W$
ENG_{33}	Average Consciousness Level of Employees on Optimal Use of Energy	Very Conscious $ENG_{33}X_1$	Indifferent (Least Conscious) $ENG_{33}X_2$		$ENG_{33}W$

*** ASEB: Assam State Electricity Board**

**** If the garden does not use solid fuels like Coal etc., then $ENG_{21}W = 0$**

7.8.3.1Computation of SPIENG

The Sector Performance Indicator of the Energy Sector is a function of the variable ETP (Energy consumption per kg of tea production) and algebraic sum of the product of scores and weightages of all the attribute factors considered.

Thus, if

$$ENGA = \Sigma\, ((ENG_i X_j) \times (ENG_i W)$$

i (factors)= 1 to 33 and j(option selected) = 1/2/3/4/5

then

SPIENG = f (ETP, ENGA).................... (7.11)

The Sect oral Performance Indicator for the Energy Sector is given by:

$SPIENG = W_{ENGV} \times$ Preference Value (ETP) + $W_{ENGA} \times$ Preference Value (ENGA).... (7.12)

Where W_{ENGV} and W_{ENGA} are the weightages assigned to the variables and attributes of the Energy Sector respectively

$$(W_{ENGV} + W_{ENGA} = 1)$$

The controlling equation for the Preference Value of ETP (Scale 0-10):

Allotted maximum = ETP_{MAX}

Allotted minimum = ETP_{MIN}

Preference Equation = $C_{ENGV} \log_{10} (ETP_i / ETP_{MAX})$............. (7.13)

Where C_{ENGV} is a constant to be found out by assigning ETP_{MAX} and ETP_{MIN}

The controlling equation for the Preference Value of ENGA (Scale 0- 10)

Maximum = $ENGA_{MAX}$

Minimum = $ENGA_{MIN}$

Preference Equation = $C_{ENGA} \log_{10} (ENGA_i / ENGA_{MIN})$........ (7.14)

Where C_{ENGA} is a constant to be found out by assigning $ENGA_{MAX}$ and $ENGA_{MIN}$

7.8.4 Modeling the Human Resource Sector

As described in Chapter VII, modeling the Human Resource Sub-sector of the Tea Garden System would lead to the derivation of SPI for Human Resource sector (SPIHR). This indicator deals with the aspects which involve the cost of maintaining the human resource in the form of salary, wages etc. Other non-tangible factors as illustrated are also included while modeling this sector for calculating the SPIHR. The causal mechanism of the factors of this sector are shown in the SD Cause & Effect diagram in Fig 7.12

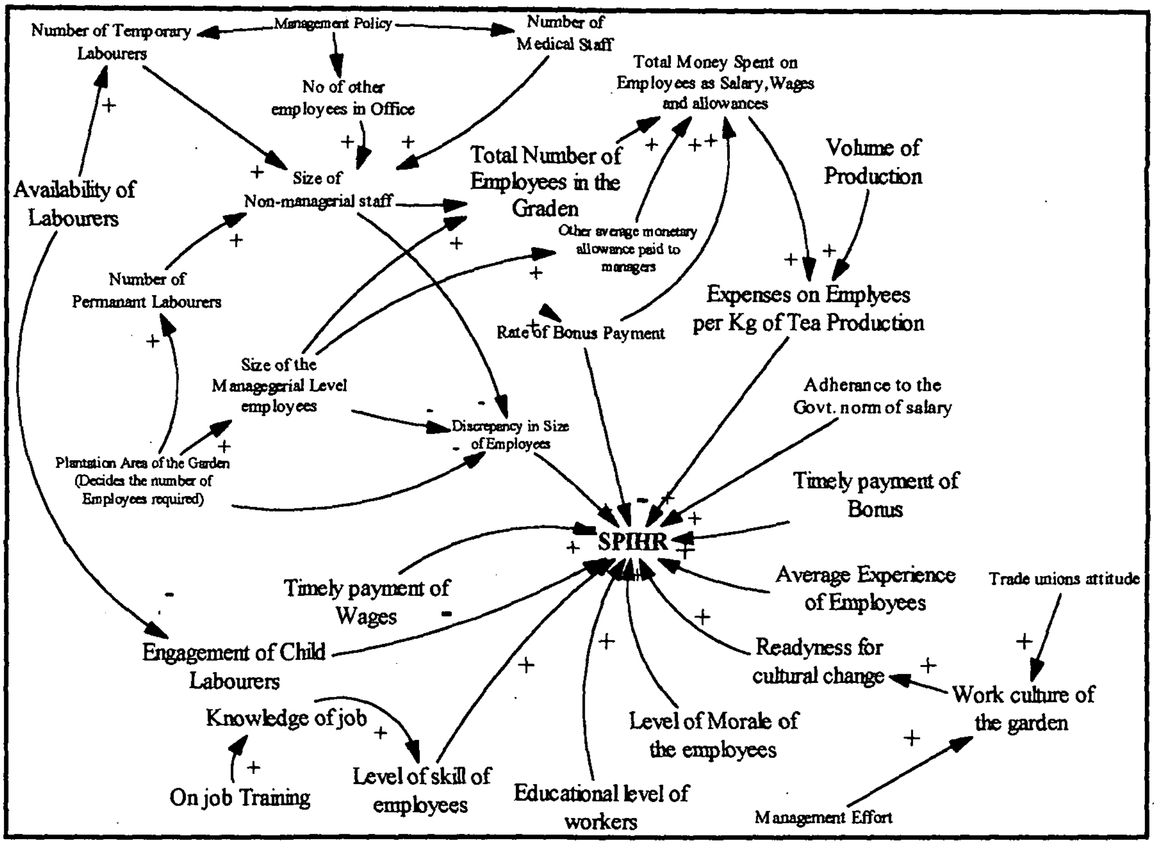


Fig. 7.12
Causal Mechanism of the Factors of Human Resource Sector

The variables and attribute factors in SPIHR model are given in Table 7.8 and 7.9 respectively.

Table7.8
Variable Factors and their Descriptions in SPIHR Model

Variable	Variable Factor Description		Unit
EPE	Amount Spent on Permanent Employees on Salary/wage Head for the Computing Period		Rupees
ETE	Amount Spent on Temporary Employees on Salary/Wage Head for the Computing Period		Rupees
BON	Bonus Paid during the Computing Period		Rupees
MBM	Amount Spent on Management Staff other than Salary during the Computing Period		Rupees
MED	Medical Expenses for Referral Treatment for All Employees in Pay-Roll for the Computing Period		Rupees
OHS	Overhead Expenses on Salary for the Computing Period		Rupees
TEHS	Total Expenses on Human Resource Sector for the Computing Period	EPE + ETE + BON + MBM + MED + OHS	Rupees
TEHSPK	Rupees per Kg of Tea Production in Human Resource Sector (This will indicate the investment on employees to produce 1 kg of made tea)	TEHS / PDN	Rupees/Kg

Table 7.9
Attributes in the Performance Indicator for the Human Resource Sector (SPIHR)

Notations (HR_i)	Factors	Levels & Scores (Based on Standard Practice and/or Data) (HR_iX_j)			Weightage (HR_iW)
HR_1	Size of Field Labour Force	Redundant HR_1X_1	Optimum HR_1X_2	Deficient HR_1X_3	HR_1W
HR_2	Average Experience of the Field Labour Force of the Garden	Highly Experienced (>10 years) HR_2X_1	Experienced (5- 10 years) HR_2X_2	Inexperienced (< 5 years) HR_2X_3	HR_2W
HR_3	Size of the Factory Labour Force	Redundant HR_3X_1	Optimum HR_3X_2	Deficient HR_3X_3	HR_3W
HR_4	Average Experience of the Factory Labour Force of the Garden	Very Much Experienced (> 15 years) HR_4X_1	Experienced (7- 15 years) HR_4X_2	Inexperienced (< 7 years) HR_4X_3	HR_4W
HR_5	Size of other Work-force of the Garden	Redundant HR_5X_1	Deficient HR_5X_2	Optimum HR_5X_3	HR_5W
HR_6	Size of Management	Redundant HR_6X_1	Deficient HR_6X_2	Optimum HR_6X_3	HR_6W
HR_7	Average Experience of Managerial Staff	Highly Experienced (> 15 years) HR_7X_1	Experienced (5-15 years) HR_7X_3	Inexperienced (< 5 years) HR_7X_3	HR_7W
HR_8	Average Experience of the Supervisory Staff	Highly Experienced (> 15 years) HR_8X_1	Experienced (5- 10 years) HR_8X_2	Inexperienced (< 5 years) HR_8X_3	HR_8W
HR_9	Regularity of Workers in their Job	Very Much Regular HR_9X_1	Irregular HR_9X_2	Very Irregular HR_9X_3	HR_9W
HR_{10}	Average Level of Communication Skill of the Workers	High $HR_{10}X_1$	Poor $HR_{10}X_2$	Very Poor $HR_{10}X_3$	$HR_{10}W$
HR_{11}	Management Perception on Motivating the Work-force	Very Difficult to Motivate $HR_{11}X_1$	Very Simple to Motivate $HR_{11}X_2$	Not Sure $HR_{11}X_3$	$HR_{11}W$
HR_{12}	Basis of Wage Payment	Volume of Work $HR_{12}X_1$	Quality of Work $HR_{12}X_2$	Both Volume and Quality $HR_{12}X_3$	$HR_{12}W$
HR_{13}	Average Level of Skill of the Work-force of the Garden	High $HR_{13}X_1$	low $HR_{13}X_2$	Very Low $HR_{13}X_3$	$HR_{13}W$
HR_{14}	General Level of Education of the Work-force of the Garden	Above Average $HR_{14}X_1$	Average $HR_{14}X_2$	Below Average $HR_{14}X_3$	$HR_{14}W$
HR_{15}	Job Knowledge of the Managerial Level Employees	Excellent, Very Much Confident $HR_{15}X_1$	Good, Confident $HR_{15}X_2$	Poor, Lacks Confidence $HR_{15}X_3$	$HR_{15}W$
HR_{16}	Average Idle-time of Garden Workers While on Duty	Above 30% $HR_{16}X_1$	10-30% $HR_{16}X_2$	Below 10% $HR_{16}X_3$	$HR_{16}W$

HR_{17}	Average Idle-time of Factory Workers While on Duty	Above 20% $HR_{17}X_1$	10-20% $HR_{17}X_2$	Below 10% $HR_{17}X_3$	$HR_{17}W$
HR_{18}	Transparency of Wage Payment System	Very Transparent, Workers Satisfied $HR_{18}X_1$	Less Transparent, Doubt in Worker's Mind $HR_{18}X_2$	Not Transparent At All $HR_{18}X_3$	$HR_{18}W$
HR_{19}	General Sense of Sanitation of the Work-force of the Garden	Satisfactory $HR_{19}X_1$	Not Satisfactory $HR_{19}X_2$		$HR_{19}W$
HR_{20}	Engagement of Child Labourers in the Garden	Not Engaged At All $HR_{20}X_1$	Sometimes/ Regularly Engaged $HR_{20}X_2$		$HR_{20}W$
HR_{21}	Learning Skill of the Employees of the Garden	Fast $HR_{21}X_1$	Slow $HR_{21}X_2$	Very Slow $HR_{21}X_3$	$HR_{21}W$
HR_{22}	General Urge of Employees for Improvement	High $HR_{22}X_1$	Low $HR_{22}X_2$		$HR_{22}W$
HR_{23}	Effective Proven Motivator for the Work-force	Money $HR_{23}X_1$	Recognition $HR_{23}X_2$	Promotion $HR_{23}X_3$	$HR_{23}W$
HR_{24}	Alcoholism Among the Workers	A Significant Problem $HR_{24}X_1$	Not Significant $HR_{24}X_2$		$HR_{24}W$
HR_{25}	Average Worker's Perception on Promotional Policy of the Garden	Quite Satisfactory $HR_{25}X_1$	Dissatisfactory $HR_{25}X_2$	Very much Dissatisfactory $HR_{25}X_3$	$HR_{25}W$
HR_{26}	Promotional Prospect for the Managerial Level Employees (as compared to other gardens)	Above average $HR_{26}X_1$	Average $HR_{26}X_2$	Below Average $HR_{26}X_3$	$HR_{26}W$
HR_{27}	Basis of Promotional policy of the Work Force	Time Bound $HR_{27}X_1$	Performance Basis $HR_{27}X_2$	Arbitrary $HR_{27}X_3$	$HR_{27}W$
HR_{28}	Basis of Promotional Policy for the Managerial Level Employees of the Garden	Time Bound $HR_{28}X_1$	Performance Basis $HR_{28}X_2$	Arbitrary $HR_{28}X_3$	$HR_{28}W$
HR_{29}	Employees are Proud for Being a Part of the Garden	Yes $HR_{29}X_1$	Indifferent $HR_{29}X_2$		$HR_{29}W$

7.8.4.1 Computation of SPIHR

The Sector Performance Indicator of the Human Resource Sector is a function of the variable TEHSPK and algebraic sum of the product of scores and weightages of all the factors considered.

Thus, if

$$HRA = \sum ((HR_i X_j) \times (HR_i W))$$

i (factors)= 1 to 29 and j(option selected) = 1/2/3

then

SPIHR = f (TEHSPK, HRA)................. (7.15)

The Sectoral Performance Indicator for the Human Resource Sector is given by:

SPIHR = W_{HRV} x Preference Value (TEHSPK) + W_{HRA} x Preference Value (HRA)..... (7.16)

Where W_{HRV} and W_{HRA} are the weightages assigned to the variables and attributes of the Human Resource Sector respectively.

$$(W_{HRV} + W_{HRA} = 1)$$

The controlling equation for the Preference Value of TEHSPK (Scale 0-10):

Allotted maximum = $TEHSPK_{MAX}$

Allotted minimum = $TEHSPK_{MIN}$

Preference Equation = $C_{HRV} \log_{10} (TEHSPK_i / TEHSPK_{MAX})$... (7.17)

Where C_{HRV} is a constant to be found out by assigning $TEHSPK_{MAX}$ and $TEHSPK_{MIN}$

The controlling equation for the Preference Value of HRA (Scale 0- 10)

Maximum = HRA_{MAX}

Minimum = HRA_{MIN}

Preference Equation = $C_{HRA} \log_{10} (HRA_i / HRA_{MIN})$.......... (7.18)

Where C_{HRA} is a constant to be found out by assigning HRA_{MAX} and HRA_{MIN}

7.8.5 Modeling the Maintenance Sector

The SPI for Maintenance sector (SPIMAINT) deals with the aspects which include the maintenance activities undertaken by the garden for the computation period. This indicator takes into account the expenses in this sector and other non-tangible factors as illustrated in Chapter VII. The causal mechanism of the factors of this sector are shown in the SD Cause & Effect diagram in Fig 7.13

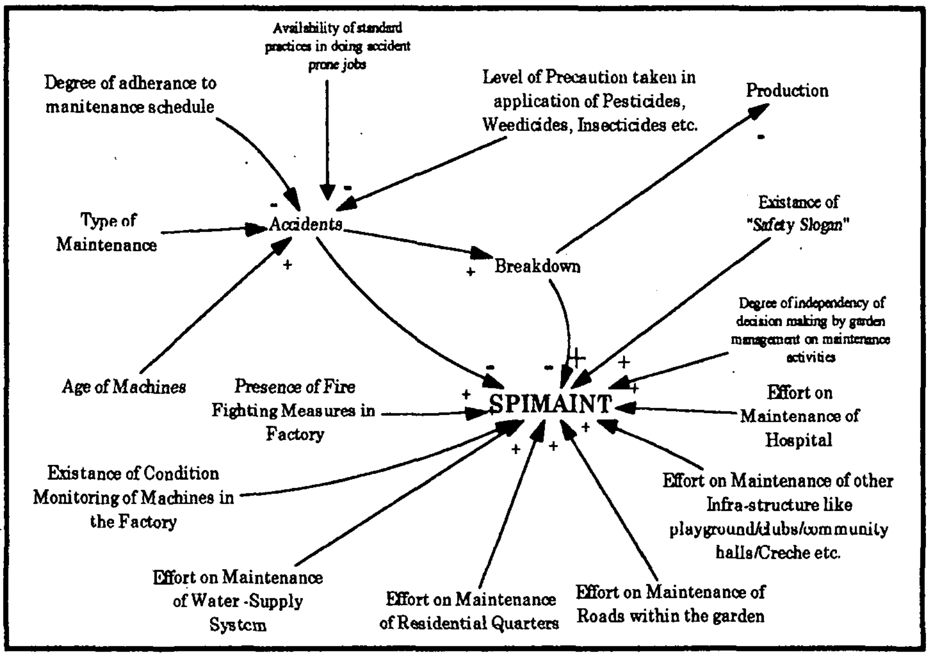


Fig. 7.13
Causal Mechanism of the Factors of Maintenance Sector

The variables and attribute factors in SPIMAINT model are given in Table 7.10 and 7.11 respectively.

Table 7.10
Variable Factors and their Descriptions in SPIMAINT Model

Variable	Variable Factor Description		Unit
EMR	Expenses Incurred on Maintenance of Roads within the Garden in the Computing Period		Rupees
EMF	Expenses Incurred on Maintenance of Factory Building in the Computing Period		Rupees
EMQ	Expenses Incurred on Maintenance of Residential Quarters in the Computing Period		Rupees
EOT	Expenses Incurred on Maintenance of Transport Vehicles of the Garden in the Computing Period		
EIF	Expenses Incurred on Maintenance of all other Infra-Structure like Hospital, Clubs, Crèche, Playgrounds, Community Hall, Water Supply System Etc. of the Garden in the Computing Period		Rupees
ECP	Amount Paid as 'Compensation' for Accidents within/outside the Factory in the Computing Period		Rupees
TMAIN	Total Expenses on Maintenance Sector in the Computing Period	EMR + EMF + EMQ + EOT + EIT + ECP	Rupees
PEMAIN	Ratio of Total Expenses on Maintenance Sector in the Computing Period to the Total Expenses Incurred by the Garden in the Computing Period	PEMAIN / TOTEXPENSE	Unit Less

Table 7.11
Attributes in the Performance Indicator for the Maintenance Sector (SPIMAINT)

Notations (MT_i)	Factors	Levels and Scores (Based on Standard Practice and/or Data) (MT_iX_j)			Weightage (MT_i W)
MT_1	Type of Maintenance in the Factory	Routine and Annual Overhauling $MT_1 X_1$	Annual Overhauling $MT_1 X_2$	Only Breakdown Maintenance $MT_1 X_3$	MT_1 W
MT_2	Garden Has Factory Maintenance Schedule	Yes $MT_2 X_1$		No $MT_2 X_2$	MT_2 W
MT_3	Status of "Safety" in the Garden	A Distinct Activity of the Garden $MT_3 X_1$		Not a Distinct Activity $MT_3 X_2$	MT_3 W
MT_4	Separate Maintenance Schedule for All Machines	Exists $MT_4 X_1$		Does Not Exist $MT_4 X_2$	MT_4 W
MT_5	Garden has a "Safety Slogan" and Followed	Yes $MT_5 X_1$		No $MT_5 X_2$	MT_5 W
MT_6	Well Designed "Guidelines" for Operation of each of the Machines	Exists and Strictly Adhered To It $MT_6 X_1$	Exists, But Not Strictly Adhered $MT_6 X_2$	Does Not Exist $MT_6 X_3$	MT_6 W
MT_7	Number of Minor Accidents Took Place in the Garden in the Computing Period	Many $MT_7 X_1$	A Few $MT_7 X_2$	None $MT_7 X_3$	MT_7 W

MT_8	Major Accidents Took Place in the Garden in the Computing Period	Yes $MT_8 X_1$	No $MT_8 X_2$		$MT_8 W$
MT_9	Condition Monitoring of the Machines in the Factory	Done Regularly $MT_9 X_1$	Done Occasionally $MT_9 X_2$	Not Done At All $MT_9 X_3$	$MT_9 W$
MT_{10}	Have Well Maintained Fire-Fighting System in the Factory	Yes $MT_{10} X_1$	No $MT_{10} X_2$		$MT_{10} W$
MT_{11}	Garden has Independent "Maintenance Crew"	Yes $MT_{11} X_1$	No $MT_{11} X_2$		$MT_{11} W$
MT_{12}	Type of Maintenance Carried Out for other Infra-Structural Facilities	Annual $MT_{12} X_1$	Half Yearly $MT_{12} X_2$	When Required $MT_{12} X_3$	$MT_{12} W$
MT_{13}	Protective Clothing During Application of Pests	Worn Every Time $MT_{13} X_1$	Not Always $MT_{13} X_2$		$MT_{13} W$
MT_{14}	Drains within the Factory	Kept Clean always $MT_{14} X_1$	Not Attended Too Much $MT_{14} X_2$		$MT_{14} W$
MT_{15}	Condition of the Hospital	Excellently Maintained* $MT_{15} X_1$	Well Maintained** $MT_{15} X_2$	Poorly Maintained*** $MT_{15} X_3$	$MT_{15} W$
MT_{16}	Condition of the Managerial Bunglows	Excellently Maintained* $MT_{16} X_1$	Well Maintained** $MT_{16} X_2$	Poorly Maintained*** $MT_{16} X_3$	$MT_{16} W$
MT_{17}	Condition of the Labour Quarters	Excellently Maintained* $MT_{17} X_1$	Well Maintained** $MT_{17} X_2$	Poorly Maintained*** $MT_{17} X_3$	$MT_{17} W$
MT_{18}	Condition of Garden Roads	Excellently Maintained* $MT_{18} X_1$	Well Maintained** $MT_{18} X_2$	Poorly Maintained*** $MT_{18} X_3$	$MT_{18} W$
MT_{19}	Condition of the Community Hall	Excellently Maintained* $MT_{19} X_1$	Well Maintained** $MT_{19} X_2$	Poorly Maintained*** $MT_{19} X_3$	$MT_{19} W$
MT_{20}	Condition of the Crèche	Excellently Maintained* $MT_{20} X_1$	Well Maintained** $MT_{20} X_2$	Poorly Maintained*** $MT_{20} X_3$	$MT_{20} W$
MT_{21}	Condition of Playgrounds	Excellently Maintained* $MT_{21} X_1$	Well Maintained** $MT_{21} X_2$	Poorly Maintained*** $MT_{21} X_3$	$MT_{21} W$
MT_{22}	Conditions of Vehicles Under Garden Control	Excellently Maintained* $MT_{22} X_1$	Well Maintained** $MT_{22} X_2$	Poorly Maintained*** $MT_{22} X_3$	$MT_{21} W$
MT_{23}	Guarding Moving Components within the Factory (Conveyors etc)	Guarded Properly $MT_{23} X_1$	No Proper Guarding $MT_{23} X_2$		$MT_{22} W$
MT_{24}	Overall Commitment of the Top Management for Maintenance Function	Very Much Committed $MT_{24} X_1$	Least Committed $MT_{24} X_2$		$MT_{23} W$

*** High Conscious Effort, Delighted Users**
**** Routine Effort, Satisfied User**
***** Little or No Effort, Dissatisfied User**

7.8.5.1 Computation of SPIMAINT

The Sector Performance Indicator of the Maintenance Sector is a function of the variable PEMAIN and algebraic sum of the product of scores and weightages of all the factors considered.

Thus If

$$MTA = \sum ((MT_i X_j) * (MT_i W))$$

i (factors)= 1 to 24 and j(option selected) = 1/2/3

then

SPIMAINT = f (PEMAIN, MTA)............... (7.19)

The Sector Performance Indicator for the Human Resource Sector is given by:

SPIMAINT = W_{MTV} x Preference Value (PEMAIN) + W_{MTA} x Preference Value (MTA)....... (7.20)

Where W_{MTV} & W_{MTA} are the weightages assigned to the variables and attributes of the Maintenance Sector respectively.

$$(W_{MTV} + W_{MTA} = 1)$$

The controlling equation for the Preference Value of PEMAIN (Scale 0-10):

Allotted maximum = $PEMAIN_{MAX}$

Allotted minimum = $PEMAIN_{MIN}$

Preference Equation = $C_{MTV} \log_{10} (PEMAIN_i / PEMAIN_{MAX})$... (7.21)

Where C_{MTV} is a constant to be found out by assigning $PEMAIN_{MAX}$ and $PEMAIN_{MIN}$

The controlling equation for the Preference Value of MTA (Scale 0- 10)

Maximum = MTA_{MAX}

Minimum = MTA_{MIN}

Preference Equation = $C_{MTA} \log_{10} (MTA_i / MTA_{MIN})$........... (7.22)

Where C_{MTA} is a constant to be found out by assigning MTA_{MAX} and MTA_{MIN}

7.8.6 Modeling the Welfare Sector

The SPI for Welfare sector (SPIWEL) deals with the aspects of welfare activities undertaken by a garden as illustrated in Chapter VII. This indicator takes into account the expenses incurred in this sector and other attribute factors. The causal mechanism of the factors of this sector is shown in the SD Cause & Effect diagram in Fig 7.14

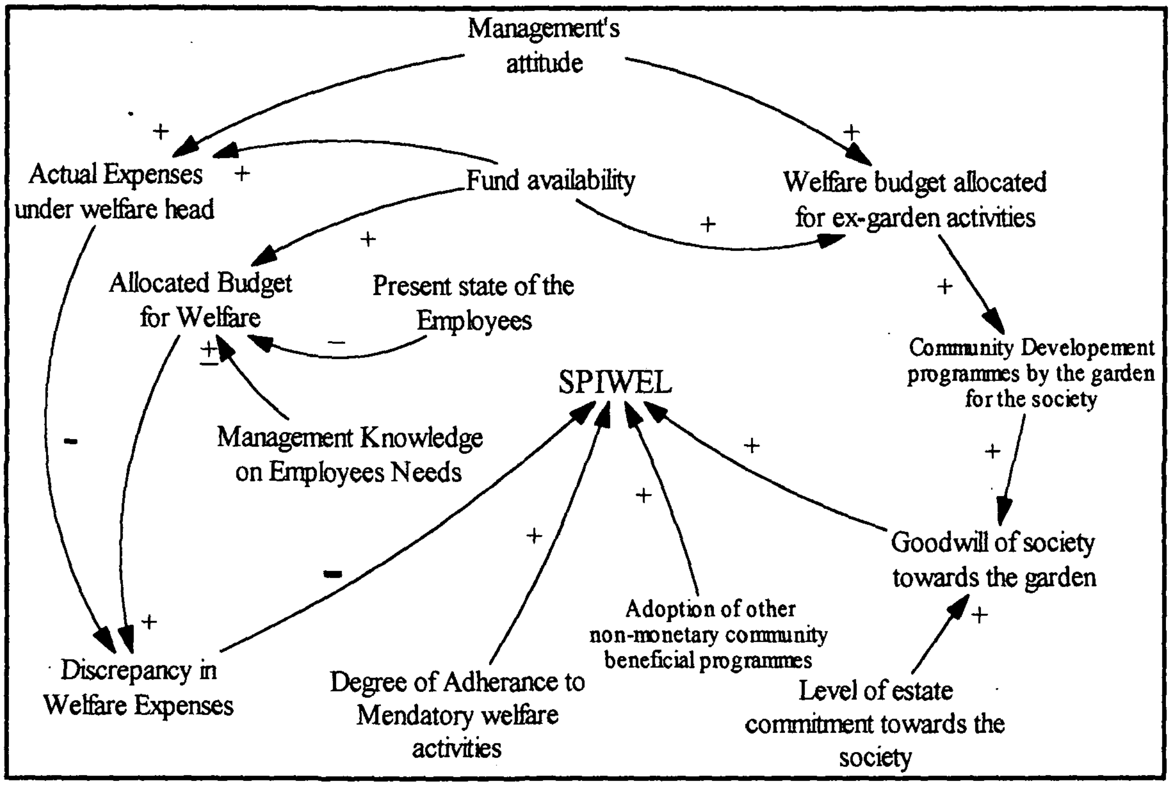


Fig. 7.14
Causal Mechanism of the Factors of Welfare Sector

The variables and attribute factors in SPIWEL model are given in Table 7.12 and 7.13 respectively.

Table 7.12
Variables Used in SPIWEL Model

Variable	Variable name/ Description		Unit
WEMP	Amount Spent for Employee Welfare activities in the Computing Period (Mandatory)		Rupees
WSOS	Amount Spent for Ex-Garden Welfare Activities in the Computing Period		Rupees
EAME	Expenses Incurred in Setting & Upgrading New Welfare Amenities of the Garden in the Computing Period (Non-Mandatory)		Rupees
EHOS	Total Operating Expenses of the Garden Hospital in the Computing Period		Rupees
EWEL	Total Expenses Under Welfare Head in the Computing Period	WEMP + WSOS + EAME + EHOS	Rupees
RWTE	Ratio of Actual Total Expenses Under Welfare Head to Total Expenditure	EWEL/TOTEXPENSE	Unit less

Table 7.13
Attributes in the Performance Indicator for the Welfare Sector (SPIWEL)

Notations (WEL_i)	Factors	Levels and Scores (Based on Standard Practice and/or Data) (WEL_iX_j)					Weightage (WEL_iW)
WEL_1	Ex-Garden Welfare Rating of the Garden	Very High WEL_1X_1	High WEL_1X_2	Moderate WEL_1X_3	Poor WEL_1X_4	Very Poor WEL_1X_5	WEL_1W
WEL_2	Level of Estate School for the Children of Employees of the Garden	Primary School WEL_2X_1	High School WEL_2X_2	No School WEL_2X_3			WEL_2W
WEL_3	Pattern of Funding the Estate School of the Garden	100% Estate Financed WEL_3X_1	Govt. Run, Infra-Structure Offered by Garden WEL_3X_2	No School WEL_3X_3			WEL_3W
WEL_4	Labour Welfare Officer in the Garden	Appointed WEL_4X_1	Not Appointed WEL_4X_2				WEL_4W
WEL_5	Activities of the Labour Welfare Officer	Garden Does Not Assign Plantation Activities to the Welfare Officer WEL_5X_1	Garden Assigns Plantation Activities to the Welfare Officer WEL_5X_2	Not Appointed WEL_5X_3			WEL_5W
WEL_6	Adherence to Norms for Supply of Protective Clothing for Pest Application	Full WEL_6X_1	Partial WEL_6X_2	Not Supplied At All WEL_6X_3			WEL_6W
WEL_7	Adherence to Norms for Supply of Concessional Cereal	As per Norms WEL_7X_1	Norms Deviated WEL_7X_2				WEL_7W
WEL_8	Crèche for Children of Working Women Labourers	Sufficient/ Good Operation WEL_8X_1	Insufficient /Poor Operation/No Crèche WEL_8X_2				WEL_8W
WEL_9	Condition of the Garden in terms of Health and Hygiene	Excellent WEL_9X_1	Good WEL_9X_2	Bad WEL_9X_3	Very Bad WEL_9X_4		WEL_9W
WEL_{10}	Emergency Health Care Facilities in the Garden	Satisfactory $WEL_{10}X_1$	Not Satisfactory $WEL_{10}X_2$				$WEL_{10}W$
WEL_{11}	Facility of General Treatment in the Hospital	Good $WEL_{11}X_1$	Moderate $WEL_{11}X_2$	Poor $WEL_{11}X_3$			$WEL_{11}W$
WEL_{12}	Size of Hospital Staff	Sufficient $WEL_{12}X_1$	Deficient $WEL_{12}X_2$				$WEL_{12}W$
WEL_{13}	Canteen Facility for the Garden Labourers	Well Maintained $WEL_{13}X_1$	Not Properly Maintained $WEL_{13}X_2$	No Canteen Facility $WEL_{13}X_3$			$WEL_{13}W$
WEL_{14}	Conformance of Labour Quarters as per Norms laid by Government	Full Conformance $WEL_{14}X_1$	Partial Conformance $WEL_{14}X_2$	Does Not Conform At All $WEL_{14}X_3$			$WEL_{14}W$

WEL_{15}	Health Consciousness Drive by the Garden	Undertaken Regularly $WEL_{15}X_1$	Undertaken Occasionally $WEL_{15}X_2$	Not undertaken at all $WEL_{15}X_3$	$WEL_{15}W$
WEL_{16}	Immunization Programme by the Garden	Undertaken Regularly $WEL_{16}X_1$	Undertaken Occasionally $WEL_{16}X_2$	Not undertaken at all $WEL_{17}X_3$	$WEL_{16}W$
WEL_{17}	Ambulance Service of the Garden	Satisfactory $WEL_{17}X_1$	Not Satisfactory $WEL_{17}X_2$		$WEL_{17}W$
WEL_{18}	Water Supply System of the Garden	Hygienically Maintained $WEL_{18}X_1$	Poorly Maintained $WEL_{18}X_2$		$WEL_{18}W$
WEL_{19}	First Aid Facility in the Garden and Factory	Present $WEL_{19}X_1$	Absent $WEL_{19}X_2$		$WEL_{19}W$
WEL_{20}	Periodicity of Drinking Water Testing	Regularly $WEL_{20}X_1$	Occasional $WEL_{20}X_2$	Never $WEL_{20}X_3$	$WEL_{20}W$
WEL_{21}	Provision of Paid Holidays	Exists $WEL_{21}X_1$	Does not exist $WEL_{21}X_2$		$WEL_{21}W$
WEL_{22}	Community Hall for Garden Labourers	Exists $WEL_{22}X_1$	Does not exist $WEL_{22}X_2$		$WEL_{22}W$
WEL_{23}	Playground for the Labourers	Exists $WEL_{23}X_1$	Does not exist $WEL_{23}X_2$		$WEL_{23}W$
WEL_{24}	Provision for Financial Assistance to Meritorious Students of the of Employees	Exists $WEL_{24}X_1$	Does not exist $WEL_{24}X_2$		$WEL_{24}W$
WEL_{25}	Policy for funding Welfare Activities Outside Garden	Exists and Strictly Adhered to it $WEL_{25}X_1$	Exists, Not Executed $WEL_{25}X_2$	Does not Exist $WEL_{25}X_3$	$WEL_{25}W$

7.8.6.1 Computation of SPIWEL

The Sector Performance Indicator of the Welfare Sector is a function of the variable RWTE and algebraic sum of the product of scores and weightages of all the attribute factors considered.

Thus, if

$$WELA = \Sigma ((WEL_i X_j) \times (WEL_i W))$$

i (factors)= 1 to 25 and j(option selected) = 1/2/3/4/5

then

SPIWEL = f (RWTE, WELA)................ (7.23)

The Sect oral Performance Indicator for the Welfare Sector is given by:

SPIWEL = W_{WELV} x Preference Value (RWTE) + W_{WELA} x Preference Value (WELA)........ (7.24)

Where W_{WELV} & W_{WELA} are the weightages assigned to the variables and attributes of the Welfare Sector respectively.

$$(W_{WELV} + W_{WELA} = 1)$$

The controlling equation for the Preference Value of RWTE (Scale 0-10):

Allotted maximum = $RWTE_{MAX}$

Allotted minimum = $RWTE_{MIN}$

Preference Equation = C_{WELV} log $_{10}$ ($RWTE_i$ / $RWTE_{MIN}$)......... (7.25)

Where C_{ENGV} is a constant to be found out by assigning $RWTE_{MAX}$ and $RWTE_{MIN}$

The controlling equation for the Preference Value of WELA (Scale 0- 10)

Maximum = $WELA_{MAX}$

Minimum = $WELA_{MIN}$

Preference Equation = C_{WELA} log $_{10}$ ($WELA_i$ / $WELA_{MIN}$)....... (7.26)

Where C_{WELA} is a constant to be found out by assigning $WELA_{MAX}$ and $WELA_{MIN}$

7. 8.7 Modeling the Management Sector

The SPI for Management sector (SPIMAN) deals with the aspects under management control to build an atmosphere of participative management within the garden. As alredy discussed in the previous Chapter, the degree of openness on the part of management for cultural transformation would only lead to TQM culture within the garden. This indicator takes into account the attribute factors depicting the willingness and effectiveness of management of the garden. The causal mechanism of the factors of this sector is shown in the SD Cause & Effect diagram in Fig 7.15

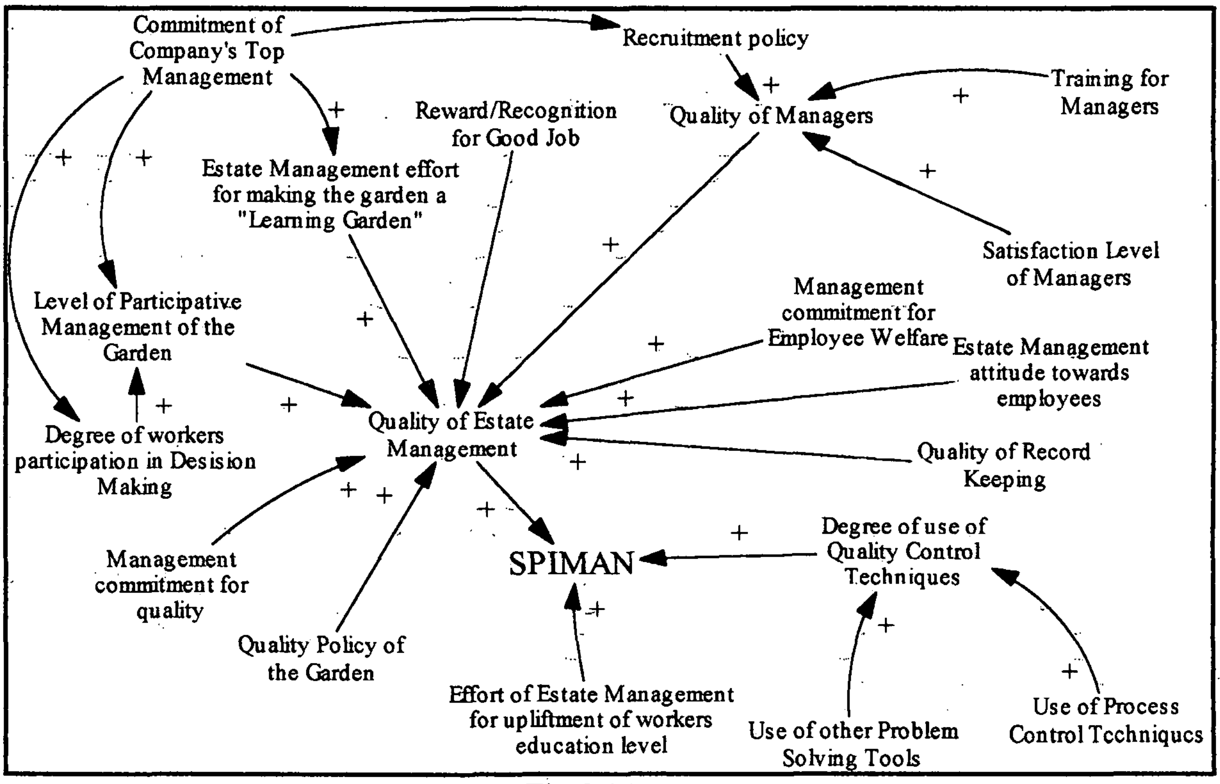


Fig. 7.15
Causal Mechanism of the Factors of Management Sector

The attribute factors in SPIMAN model are given in Table 7.14

Table 7.14
Attributes in the Performance Indicator for the Management Sector (SPIMAN)

Notations (MAN_i)	Factors	Levels and Scores (Based on Standard Practice and/or Data) (MAN_iX_j)			Weightage (MAN_iW)
MAN_1	Level of Commitment of the Top Management for the Development of the Garden	High MAN_1X_1	Low MAN_1X_2	Very Low MAN_1X_3	MAN_1W
MAN_2	"Quality Policy" of the Garden	Well Defined and Organized Effort for Attainment MAN_2X_1	Exists but Not Known to All MAN_2X_2	No Quality Policy MAN_2X_3	MAN_2W
MAN_3	Level of Participative Management in the Garden	High MAN_3X_1	Low MAN_3X_2	Poor MAN_3X_3	MAN_3W
MAN_4	Knowledge of Managerial Level People about the Factors Affecting Quality of Made Tea	High MAN_4X_1	Low MAN_4X_2	Poor MAN_4X_3	MAN_4W

MAN_5	Garden's Status as "Learning Organization"	High MAN_5X_1	Low MAN_5X_2	No 'Learning Concept' at all MAN_5X_3		MAN_5W
MAN_6	Rejection/ Low Price Realization of Lots of Garden Tea due to Poor Quality	Yes MAN_6X_1	No MAN_6X_2			MAN_5W
MAN_7	Level of Informal Interaction among the Managerial and Non-Managerial Staff	High MAN_7X_1	Low MAN_7X_2	Poor MAN_7X_3		MAN_7W
MAN_8	Use of Process Control Tools in Production	Used Extensively MAN_8X_1	Used in Certain Cases MAN_8X_2	Not Used at all MAN_8X_3		MAN_8W
MAN_9	Use of Organized Problem Solving Techniques in the Garden	Used Extensively MAN_9X_1	Used in Certain Cases MAN_9X_2	Not Used at all MAN_9X_3		MAN_9W
MAN_{10}	Management's Relation with the Trade Union	Harmonious $MAN_{10}X_1$	Conflicting $MAN_{10}X_2$			$MAN_{10}W$
MAN_{11}	Existence of Quality Circles, Problem Solving Groups where Non-Managerial People are also included	Exists and Functions Extensively $MAN_{11}X_1$	Exists But Poor Functioning $MAN_{11}X_2$	Does not Exist $MAN_{11}X_3$		$MAN_{11}W$
MAN_{12}	Garden Financed Research and Development Activities	Sizable Numbers $MAN_{12}X_1$	A Few $MAN_{12}X_2$	No Any $MAN_{12}X_3$		$MAN_{12}W$
MAN_{13}	Labour Strike in the Computing Period	Yes $MAN_{13}X_1$	No $MAN_{13}X_2$			$MAN_{13}W$
MAN_{14}	Lock-out of the Garden in the Computing Period	Yes $MAN_{14}X_1$	No $MAN_{14}X_2$			$MAN_{14}W$
MAN_{15}	Provision for Rewarding Employees for Good Work	A Common Practice $MAN_{15}X_1$	Sometimes $MAN_{15}X_2$	No Such Provision $MAN_{15}X_3$		$MAN_{15}W$
MAN_{16}	Mode of Rewarding Employees	Monetary $MAN_{16}X_1$	Promotion $MAN_{16}X_2$	Acknowledged Publicly $MAN_{16}X_3$	No Provision $MAN_{16}X_4$	$MAN_{16}W$
MAN_{17}	General Morale of Employees of the Garden	Very High $MAN_{17}X_1$	Satisfactory $MAN_{17}X_2$	Low $MAN_{17}X_3$		$MAN_{17}W$
MAN_{18}	Training Programme for Managerial Level People	Conducted Regularly $MAN_{18}X_1$	Conducted Rarely $MAN_{18}X_2$	Not Conducted at all $MAN_{18}X_3$		$MAN_{18}W$
MAN_{19}	On Job Training Programme for Employees of the Garden	Conducted Regularly $MAN_{19}X_1$	Conducted Rarely $MAN_{19}X_2$	Not Conducted at all $MAN_{19}X_3$		$MAN_{19}W$
MAN_{20}	Record Keeping in all aspects of the Garden	Systematic $MAN_{20}X_1$	Haphazard $MAN_{20}X_2$	No Record Keeping $MAN_{20}X_3$		$MAN_{20}W$

MAN_{21}	Theft of Tea Leaves of the Garden	A Serious Problem for the Garden $MAN_{21}X_1$	Not A Serious Problem For the Garden $MAN_{21}X_2$			$MAN_{21}W$
MAN_{22}	Theft of Made Tea of the Garden	A Serious Problem for the Garden $MAN_{22}X_1$	Not A Serious Problem For the Garden $MAN_{22}X_2$			$MAN_{22}W$
MAN_{23}	Use of Computers in the Garden Activities	Extensive $MAN_{23}X_1$	In some Aspects only $MAN_{23}X_2$	Not used at all $MAN_{23}X_3$		$MAN_{23}W$
MAN_{24}	Fixation of Span of Control of Asstt. Managers, Sirders, Supervisors	Based on Experience $MAN_{24}X_1$	Traditional $MAN_{24}X_2$			$MAN_{24}W$
MAN_{25}	Leadership Capability of the Managerial Staff	Very High $MAN_{25}X_1$	Satisfactory $MAN_{25}X_2$	Low $MAN_{25}X_3$		$MAN_{25}W$
MAN_{26}	Worker's Knowledge about Plantation and Processing Aspects Contributing to Quality of Tea	High $MAN_{26}X_1$	Low $MAN_{26}X_2$			$MAN_{26}W$
MAN_{27}	Employees Follow Instructions of Managers/Sirdars of the Garden	As they Love to Work $MAN_{27}X_1$	As, they fear of Punishment $MAN_{27}X_2$			$MAN_{27}W$
MAN_{28}	Conflict between Employees and Managers	Never $MAN_{28}X_1$	A Regular Affair $MAN_{28}X_2$			$MAN_{28}W$
MAN_{29}	Employees Are Proud of Being a Pert of the Garden	Yes $MAN_{29}X_1$	No $MAN_{29}X_2$	Indifferent $MAN_{29}X_3$		$MAN_{29}W$
MAN_{30}	Rate of Bonus Paid in the Computing Period	8.33% $MAN_{30}X_1$	> 8.33 but < 15% $MAN_{30}X_2$	> 15% $MAN_{30}X_3$	No Bonus Paid at all $MAN_{30}X_4$	$MAN_{30}W$
MAN_{31}	Mode of Bonus Payment in the Computing Period	Single Installment $MAN_{31}X_1$	>1 Installment $MAN_{31}X_2$	Not Paid at all $MAN_{31}X_3$		$MAN_{31}W$
MAN_{32}	Decision on 'Rate of Bonus Payment'	Decided after Consultation with the Trade Union $MAN_{32}X_1$	Decided Unilaterally $MAN_{32}X_2$			$MAN_{32}W$
MAN_{33}	Period of Bonus Payment	Before Festivals $MAN_{33}X_1$	After Festivals $MAN_{33}X_2$	Not paid at all $MAN_{33}X_3$		$MAN_{33}W$
MAN_{34}	Management's Readiness for Initiation of Cultural Change	Ever-Ready Set of Management $MAN_{34}X_1$	Probable Resistance may result $MAN_{34}X_2$			$MAN_{34}W$
MAN_{35}	Employee's Readiness for Cultural Change	Ever- Ready; Tuned Set of Employees $MAN_{35}X_1$	Probable Obstacle for Change $MAN_{35}X_2$			$MAN_{35}W$

7.8.7.1 Computation of SPIMAN

The Sector Performance Indicator of the Management Sector is a function of the algebraic sum of the product of scores and weightages of all the attribute factors considered.

Thus, if

$MANA = \Sigma ((MAN_i X_j) \times (MAN_i W)$

i (factors)= 1 to 35 and j(option selected) = 1/2/3/4

then **SPIMAN = f (MANA)........................ (7.27)**

The Sector Performance Indicator for the Management Sector is given by:

SPIMAN = Preference Value (MANA).............. (7.28)

The controlling equation for the Preference Value of MANA (Scale 0- 10)

Maximum = $MANA_{MAX}$

Minimum = $MANA_{MIN}$

Preference Equation = $C_{MANA} \log_{10} (MANA_i / MANA_{MIN})$......... (7.29)

Where C_{MANA} is a constant to be found out by assigning $MANA_{MAX}$ & $MANA_{MIN}$

7.9 Computation of TQMI of the Garden

The computation of the TQMI of the garden for the computing period is given in Table 7.15 below

Table 7.15
Computation of TQMI

Sectors	SPI (SPI_i)	Weightage ($SPI_i W$)	TQMI
Garden	$SPI_1 = SPIG$	$SPI_1 W_1 = SPIGW$	TQMI = SPIG x SPIGW + SPIHR x SPIHRW + SPIENG x SPIENGW + SPIMAINT x SPIMAINTW + SPIMAN x SPIMANW + SPIPROC x SPIPROCW + SPIWEL x SPIWELW = $\Sigma (SPI_i) \times (SPI_i W_i)$..........(7.30) (i = 1 to 7)
Processing	$SPI_2 = SPIPROC$	$SPI_2 W_2 = SPIPROCW$	
Energy	$SPI_3 = SPIENG$	$SPI_3 W_3 = SPIENGW$	
Human Resource	$SPI_4 = SPIHR$	$SPI_4 W_4 = SPIHRW$	
Maintenance	$SPI_5 = SPIMAINT$	$SPI_5 W_5 = SPIMAINTW$	
Welfare	$SPI_6 = SPIWEL$	$SPI_6 W_6 = SPIWELW$	
Management	$SPI_7 = SPIMAN$	$SPI_7 W_7 = SPIMANW$	
		$\Sigma SPI_i W_i = 1.00$ (i = 1 to 7)	

7.10 Base Score for Performance Indicator of a Garden

The base score which mainly takes care of the management uncontrollable factors, as considered in this model, is computed as given in Table 7.16

Table 7.16
Table for Factors Contributing to the Base Score

FACTORS ($BASE_f$)	**WEIGHTAGE ($BASE_f W$)**	**LEVELS AND SCORES ($BASE_f X_j$)**				
Altitude (m)	ALT_W	* KEPT LEVEL CONSTANT				
Average length of the day (Hour)	LTH_W	< 12.0 hours LTH_1	12.0 – 12.5 hours LTH_2	> 12.5 hours LTH_3		
Average rainfall during November – December (mm)	$RFND_W$	< 50 $RFND_1$	50 to 60 $RFND_2$	> 60 $RFND_3$		
Average rainfall during January - March (mm)	$RFJM_W$	< 70 $RFJM_1$	70 - 80 $RFJM_2$	> 80 $RFJM_3$		
Maximum environmental temperature (°C)	$ETMAX_W$	>40 $ETMAX_1$	35 to 40 $ETMAX_2$	< 35 $ETMAX_3$		
Minimum environmental temperature (°C)	$ETMIN_W$	< - 2 $ETMIN_1$	-2 to 4 $ETMIN_2$	> 4 $ETMIN_3$		
Organic Carbon Content of Soil (%)	C_W	Below 0.6 C_1	0.61 – 1.00 C_2	> 1.00 C_3		
Location of the Garden	$LOCG_W$	Rainy Area $LOCG_1$	Drought Area $LOCG_2$			
Location of the Head Office of the Garden	$LOCHO_W$	Within the State $LOCHO_1$	Outside the State $LOCHO_2$			
Soil pH	PH_W	Below 4.5 PH_2	4.5 – 5.5 PH_2	> 5.6 PH_3		
Soil Bulk Density (Gram / cc)	BD_W	<1.20 BD_1	1.21 to 1.40 BD_2	1.41 to 1.60 BD_3	1.61 to1.70 BD_4	> 1.70 BD_5
Land profile of the Garden	$LAND_W$	High Land $LAND_1$	Flood Affected Area $LAND_2$			

*** Variation in altitude in the tea growing areas of Assam does not provide any leverage to any garden as the magnitude of variation is negligible. So the effect of this factor is neglected.**

7.10.1 Computation of BASESCORE:

The base score for PI is the algebraic sum of the product of scores and weightages of all the factors considered.

Thus, if

$BASE = \sum((BASE_i X_j) \times (BASE_i W)$

i (factors)= 1 to 12 and j(option selected) = 1/2/3/4/5

then

BS = f (BASE)...................... (7.31)

The Base Score is given by:

BS = Preference Value (BASE)................... (7.32)

The controlling equation for the Preference Value of BASE (Scale 0- 10)

Maximum = $(BASE)_{MAX}$

Minimum = $(BASE)_{MIN}$

Preference Equation = $C_{BASE} \log_{10} (BASE_i / BASE_{MIN})$............. (7.33)

Where C_{BASE} is a constant to be found out by assigning

$BASE_{MAX}$ & $BASE_{MIN}$

7.11 Computation of Garden Performance Indicator

The computation of the PI from TQMI (equation (7.30)) and BS (equation (7.33)) of the garden for the computing Period is shown in Table 7.17 below

Table 7.17
Computation of Performance Indicator of the Garden

FACTORS	VALUE	WEIGHTAGE	PI
TQMI	TQMI	W_{TQMI}	**PI = TQMI x W_{TQMI} + BS x W_{BS}**
BASE SCORE	BS	W_{BS}	
		$W_{TQMI} + W_{BS} = 1.00$	

7.12 Applications of the Model

The proposed model for TQMI is based on expected standard practices in the different sectors of tea plantation. This model may be useful in:

- Assessing the standing of a garden in terms of all-round quality. Sector-wise continuous improvement effort must follow after assessment. In other words, TQMI for the first-time-assessment is to be treated as the 'starting point' for continuous improvement efforts
- Finding the weak areas (sub-systems) of the garden needing more attention for improvement. (The SPIs will indicate these areas)
- Degree of improvement achieved in SPIs or TQMI in subsequent assessment by the garden
- Comparing performance of gardens under the same management for identifying the garden(s) and their sectors needing more attention

7.13 Limitations of the Model

The model involves number of factors which are subjective in nature and need to assign scores on their subjective preference. Therefore, unless a consensus is reached on the scores and weightages among the hundreds of gardens of Assam, this model cannot be used for comparing performance of two gardens under two different management.

CHAPTER – VIII

Computation of TQMI and PI of Tea Gardens

8.1 TQMI and PI Computation

The calculation of Total Quality Management Indicator (TQMI) and Performance Indicator (PI) of a garden involves lot of computations. If done manually, it will consume lot of time. To get rid of this problem, a software for computation of TQMI and PI has been developed which is being included as an independent module in an Information System developed on Assam Tea (Chapter IX). The executable program developed in Visual Basic (TQMI.exe) deals with the computation of TQMI of a tea garden. This module provides the numerical value of TQMI of a garden at a specific time in a scale of 0 – 10 for a set of inputs of attribute and variable data for a garden.

In this chapter an attempt has been made to compare the performance of sample tea gardens by computing their TQMI and PI for a specific period. As discussed in Chapter VII, the computation of TQMI and PI needs the values of level scores and weightages of different factors. Assignments of the scores and weightages to various factors have been discussed in following sections.

8.2 Assignment of Scores to Different Levels of Attribute Factors

As discussed, the levels of the attribute factors which dictate the conditions prevailing in a garden need to be assigned scores. These scores are functions of different states in context of the factor. In order to compare the performance of two gardens, the relative values of the scores of all the factors are obtained by discussion with the persons involved in the field of Tea Management. However, an integrated approach involving the persons related to Tea Management, Research and Tea Consultancy would help in establishing the standard scores and weightages to be used universally.

The scores used for different levels in the TQMI model are based on:

- Feedback from tea management of different gardens
- Feedback from Quality consultants
- Standards available

The scores so obtained, for various levels of the attribute factors of different sectors are tabulated in Appendix V-A. The scores for base factors used in the TQMI model are given in Appendix V-B.

8.3 Assignment of Weightage to Different Attribute Factors

The attribute factors which are treated as intangible in nature need to be assigned weightages. These weightages are functions of their relative importance in context of total quality performance of tea gardens. The relative values of the weightages of all the factors are to be obtained by discussion with the persons involved in the field of Tea Management, Research and Tea Consultancy. As a consequence, they are purely subjective in nature. However, an integrated approach involving the management authorities of different tea gardens would help in evolving the standard scores and weightages to be used universally. **This would facilitate performance comparison of different gardens under different management.**

In the TQMI module of the Information System, flexibility in weightage assignment has been incorporated by asking the user to put relative weightage for various factors. The resulting weightage for a factor is computed as shown below:

For a Sector consisting of 'n' numbers of attribute factors, if the individual weightages are W_{1F}, W_{2F}, W_{3F},........................ W_{nF} of factors F_1, F_2 F_3........... F_n respectively, then the relative weightage in a (0 – 1) scale for:

$$\text{Factor } F_1 = W_{1F} = W_1 / \Sigma(W_1 + W_2 + W_3 + \ldots + W_n)$$

$$\text{Factor } F_2 = W_{2F} = W_2 / \Sigma(W_1 + W_2 + W_3 + \ldots + W_n)$$

$$\text{Factor } F_n = W_{nF} = W_n / \Sigma(W_1 + W_2 + W_3 + \ldots + W_n)$$

Such that,

$$\sum_{i=0}^{n} W_{iF} = 1$$

The effect of a factor can be nullified by assigning 'zero individual weightage' to the factor.

The weightages for various attribute factors (W_i) tabulated in Appendix V-C are derived from:

- Standards available/ usual practice followed
- Knowledge base of Tea Management and Tea Experts (through question-answer)

These values can be suitably used for performance evaluation and comparison of performance of a Tea garden at specific time intervals. If these values are uniformly used by different tea gardens, inter garden performance comparison will also be possible. However, these values are subjective and based on sample survey. As such, a consensus, amongst concerned parties will be needed for their universal acceptability.

8.4 Weightage Assigned to the SPIs for Determination of the TQMI

As already stated, each of the Sectors in the model bears varying degree of importance in assessing the degree of TQM Culture prevailing in the garden. The set of weightages assigned by one garden for calculation of TQMI may not be same for another garden. As no substantial background has been established for the relative importance of the sectors, it has been decided to keep the weightage open for the user. The weightage policy for a garden using this model for comparing performance for a period, or a Company comparing performance of their gardens must be consistent.

8.5 Assignment of Maximum and Minimum Values to the Variable Factors

The maximum and minimum values to the different variable factors are based on;

- different standards followed by tea gardens
- findings in literature on tea

The maximum and minimum values used in the TQMI model for various variable factors are given in Appendix V-D

8.6 Experimental Computation of TQMI of Sample Gardens

In order to validate the TQMI model, all the attribute and variable data were collected from three tea gardens. Two of the gardens are located in the Tinsukia district of Assam and one located in Dibrugarh district of Assam. The data for the gardens were collected on the pre-condition that the identity of the gardens will be kept unpublished. So the gardens are designated as Garden -1, Garden- 2 and Garden 3. Garden 1 and Garden 2 are under the same management and Garden 3 is under different management. For the purpose of comparing the performance of two gardens working under two separate management uniform scores and weightages have been assumed for both the gardens.

The data for all the attribute and variable factors were collected through questionnaire survey. For ease of providing data by the Managers of the corresponding gardens variable data are collected in an aggregative manner. (Refer Appendix I-B)

8.6.1 Computation of TQMI and PI of the Gardens Under Same Management (Intra Garden Comparison)

The characteristics of the gardens (Garden 1 and Garden 2) are:

- both the gardens are under the same management (company)
- the Head Office of the group is located in Assam
- the gardens are located 25 kilometers apart
- garden – 1 is 5 kilometers away from the nearest town and garden – 2 is 15 Km away from the nearest town
- the soil characteristics do not resemble
- both the gardens fall under Rainy area
- rainfall, length of the day, maximum and minimum environmental temperature, humidity are identical
- both the gardens are located on 'high land'

Some of the vital data of both the gardens (as supplied by the Managers of the estates) are given in Table 8.1

Table 8.1
Overall Information of the Garden-1 and Garden-2 Under Study

Factors	Garden-1	Garden - 2
Total area of the garden (Hectare)	1287.60	1027.20
Production of all types of tea (Kg)	1399556	735531
% Area under cultivation (area under bush)	75.46	65.27
Average price realized in auction (Rs)	67.45	57.23
Total number of employees	1284	927
% of area unutilized within the garden	7%	15%
Amount spent on employees (Rs)	40517146.00	21845278.00
Amount spent on welfare activities (Rs)	8275560.00	3574692.00
Amount spent on maintenance activities (Rs)	6535786.00	3654119.00
Amount spent on energy head (Rs)	7968075.00	4766242.00
Amount spent on field activities (Rs)	23941351.00	12543162.00
Dryer fuel	TD oil and Natural Gas	TD oil and Natural Gas
Dryer used	ECP	ECP
Recirculation of waste heat	No	No

Major problem in the plantation and production	Theft of green leaf and made tea	Theft of green leaf and made tea
Major problem faced by management from the labour force	Absenteeism and Alcoholism	Absenteeism and Alcoholism
Motivation level of employees	Low	Very low
General education level of labour force	Poor	Poor
Management emphasis on quality improvement	Moderate	Low
Rate of bonus paid in the period	17%	17%
Number of major accidents	None	None
Plantation type	Mixed	Mixed
Ex-garden welfare activities	Poor	Poor
Appointment of Welfare Officer in the garden	Appointed	Appointed
Basis of wage payment	Volume Plucked	Volume plucked
Yield in last five years	Stable	Decreasing
Quality Circle, Concept of Participative Management *	Absent	Absent
Training for Managerial level employees	Sometimes	Rare
Training for Labour force	Never	Never

* Management of Garden-2 do not believe that labourers are capable of finding solutions estate problems while in case of garden-1, the belief is opposite

** Data correspond to the period 2003-2004

8.6.2 Computation of TQMI and PI of the Gardens under Different Management (Inter Garden Comparison)

The characteristics of the Garden 3 are stated below:

- Garden-3 is under different management unlike the other two gardens
- the Head Office of the garden is located outside the state
- the garden is nearly 15 kilometers away from the nearest town
- tea region for this garden also falls under Rainy area
- rainfall, length of the day, maximum and minimum environmental temperature, humidity are almost identical with Garden – 1 and Garden - 2
- the garden is located on 'high land'

Some vital data of the garden (as supplied by the Manager of the estate) are given in Table 8.2.

Table 8.2
Overall Information of the Garden-3

Factors	Garden-3
Total area of the garden (Hectare)	469.35
Production of all types of tea (Kg)	700576
% Area under cultivation (area under bush)	71.86
Average price realized in auction (Rs)	58.97
Total number of employees	824
% of area unutilized within the garden	5%
Amount spent on employees (Rs)	18779640.00
Amount spent on welfare activities (Rs)	4684121.00
Amount spent on maintenance activities (Rs)	2819047.00
Amount spent on energy head (Rs)	2965538.00
Amount spent on field activities (Rs)	12080102.00
Dryer fuel	Natural Gas
Dryer used	ECP
Recirculation of waste heat	No
Major problem in the plantation and production	Theft of green leaf and made tea
Major problem faced by management from the labour force	Absenteeism and alcoholism
Motivation level of employees	Low
General education level of labour force	Very poor
Management emphasis on quality improvement	High
Rate of bonus paid in the period	15%
Number of major accidents	None
Plantation type	Mixed
Ex-garden welfare activities	Poor
Appointment of Welfare Officer in the garden	Not appointed
Basis of wage payment	Volume plucked
Yield in last five years	Constant
Quality Circle, Concept of Participative Management *	Absent
Training for Managerial level employees	Occasional
Training for Labour force	Never

* Management of the Garden believe that labourers are capable of finding solutions to many production problems
** Data correspond to the period 2003-2004

The responses from the gardens (Appendix-IB) have been used as input to the TQMI software of the Tea Information System. The same set of weightages has been used to compute the TQMI and PI for all the gardens. SPIs have been computed by assigning weightages to various attribute and variable factors as given in Table 8.3

Table 8.3
Weightage Assigned to Attribute and Variable Factors of SPIs

SPI	Weightage to Variable Factor	Weightage to Attribute factor
SPIG	0.35	0.65
SPIPROC	0.15	0.85
SPIMAINT	0.30	0.70
SPIENG	0.40	0.60
SPIWEL	0.35	0.65
SPIHR	0.25	0.75

The weightages assigned to various SPIs are shown in Fig 8.1

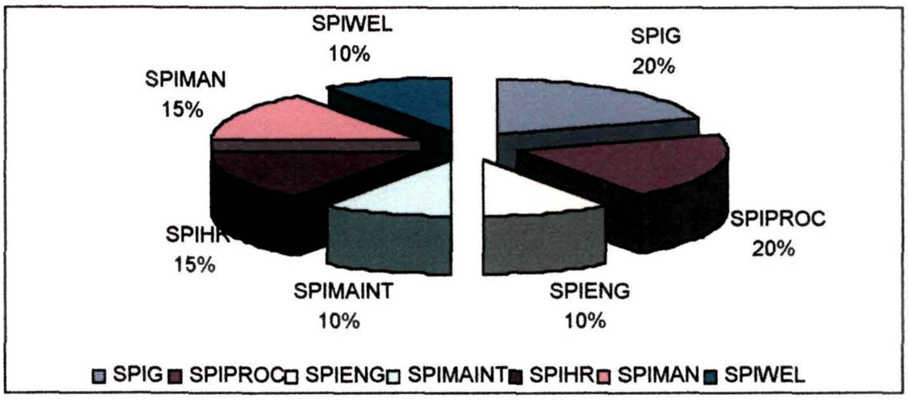


Fig 8.1
Weightage Assigned to Various SPIs

8.6.3 The Results of TQMI Computation

The results for the TQMI computation of the gardens are shown in Fig 8.2, Fig 8.3 and Fig 8.4

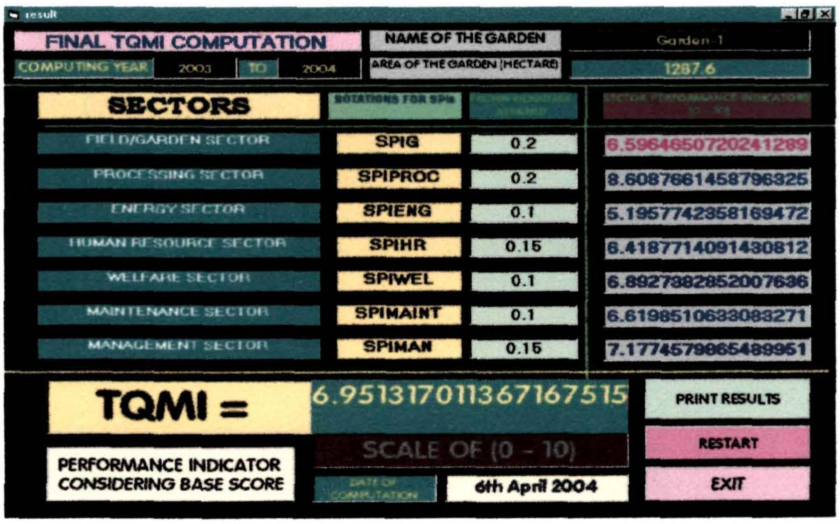


Fig 8.2
The Output for TQMI of Garden-1

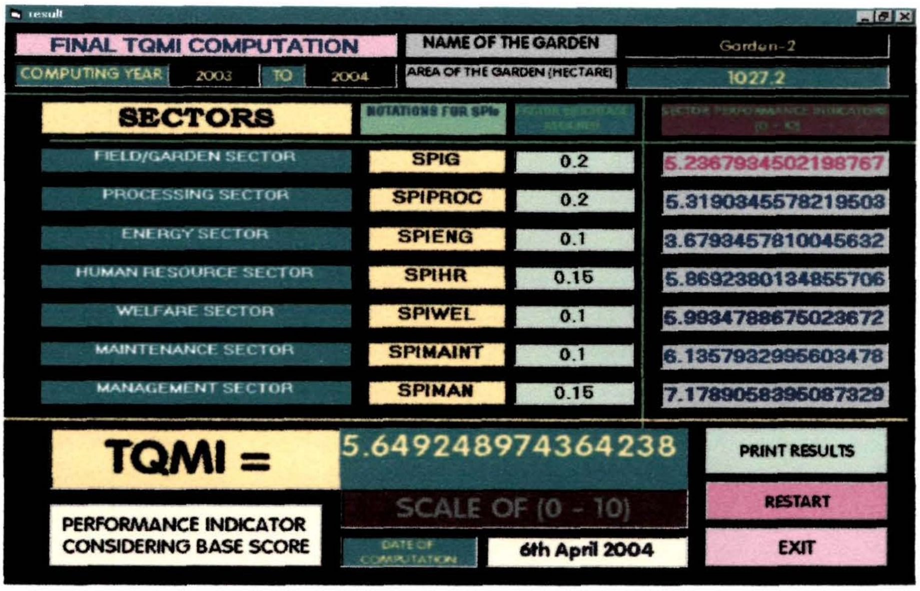


Fig 8.3
The Output for TQMI of Garden-2

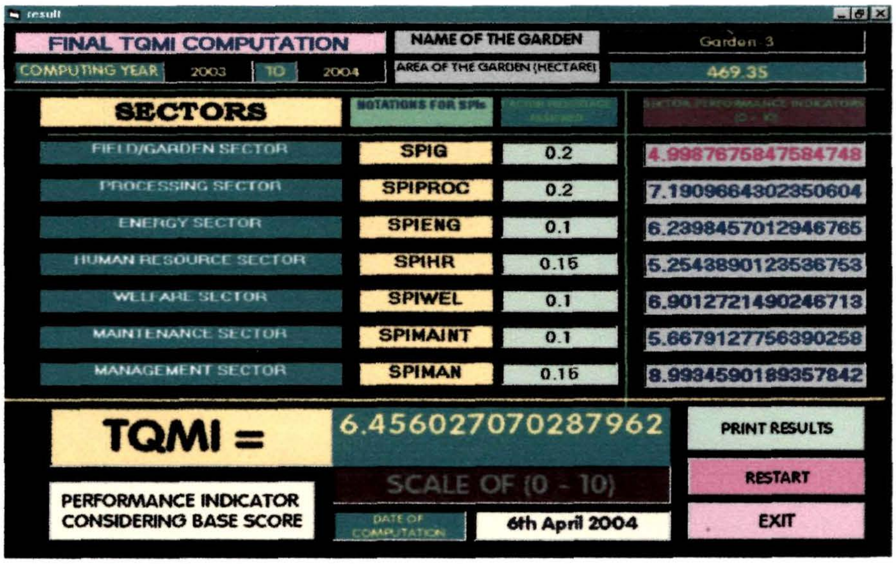


Fig 8.4
The Output for TQMI of Garden-3

8.6.4 Computation of PI of the Gardens

In order to compute the PI of the gardens, an assignment of weightage has been assumed as shown in Fig 8.5

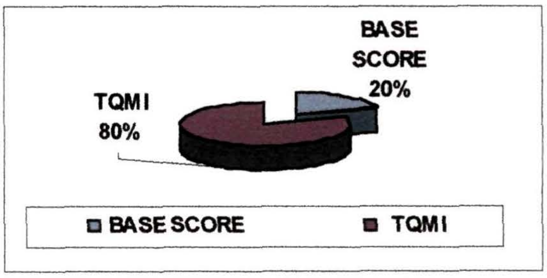
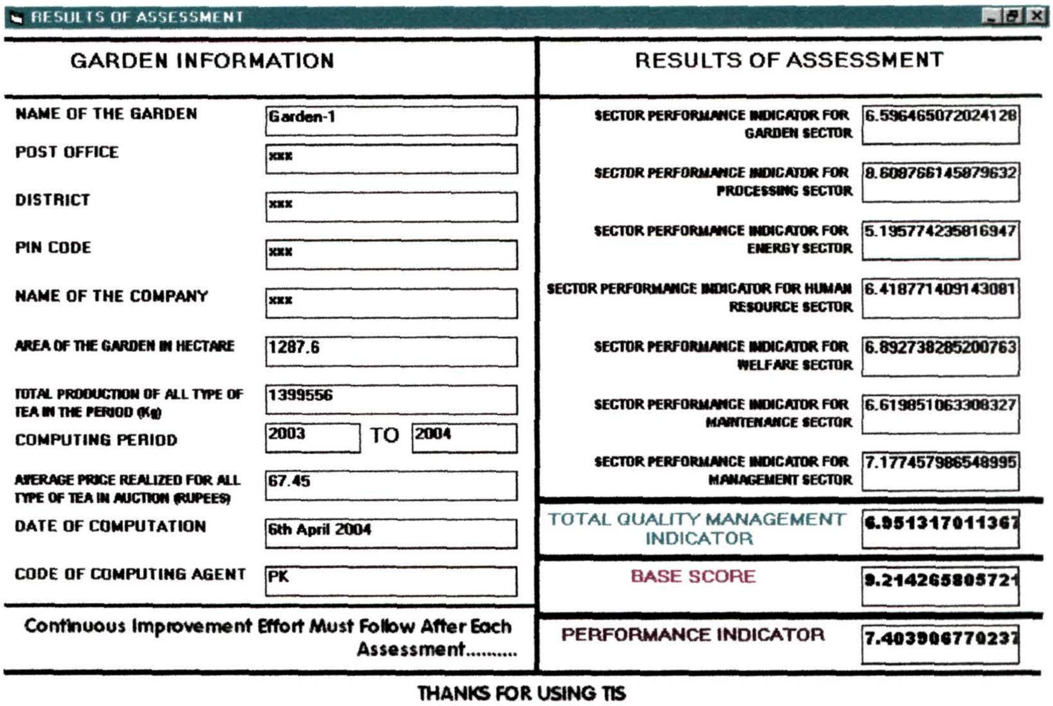


Fig. 8.5
Assignment of Weightage for Computation of PI

The results for the PI of the gardens are shown in Fig 8.6, Fig 8.7 and Fig 8.8



RESULTS OF ASSESSMENT

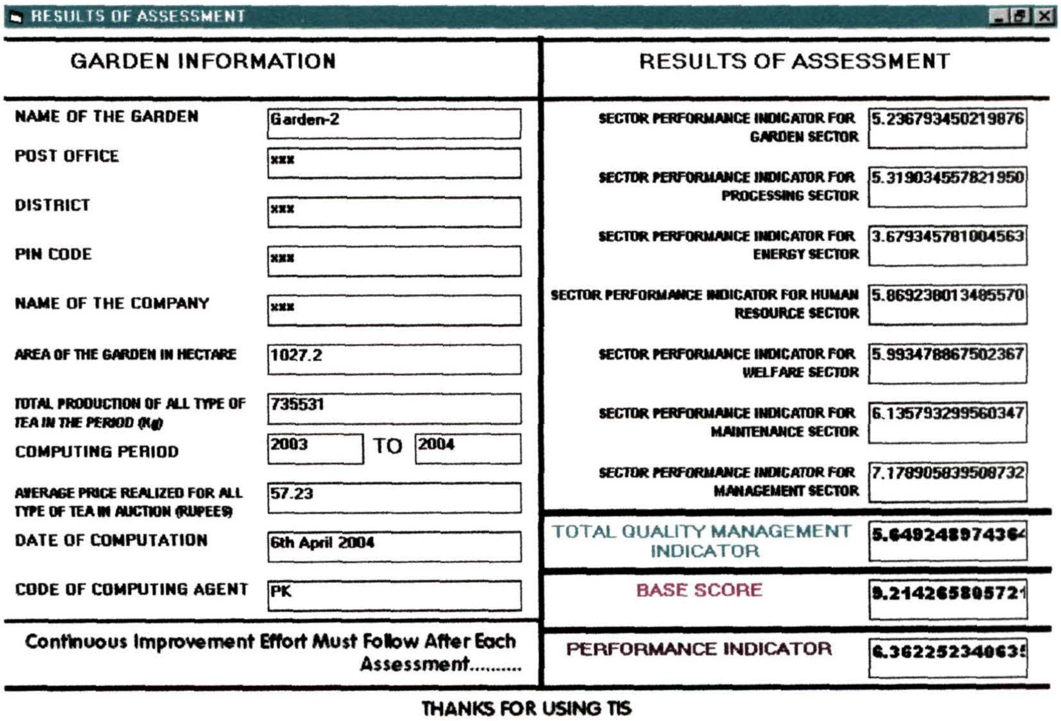
GARDEN INFORMATION	
NAME OF THE GARDEN	Garden-1
POST OFFICE	xxx
DISTRICT	xxx
PIN CODE	xxx
NAME OF THE COMPANY	xxx
AREA OF THE GARDEN IN HECTARE	1287.6
TOTAL PRODUCTION OF ALL TYPE OF TEA IN THE PERIOD (Kg)	1399556
COMPUTING PERIOD	2003 TO 2004
AVERAGE PRICE REALIZED FOR ALL TYPE OF TEA IN AUCTION (RUPEES)	67.45
DATE OF COMPUTATION	6th April 2004
CODE OF COMPUTING AGENT	PK

RESULTS OF ASSESSMENT	
SECTOR PERFORMANCE INDICATOR FOR GARDEN SECTOR	6.596465072024128
SECTOR PERFORMANCE INDICATOR FOR PROCESSING SECTOR	8.608766145879632
SECTOR PERFORMANCE INDICATOR FOR ENERGY SECTOR	5.195774235816947
SECTOR PERFORMANCE INDICATOR FOR HUMAN RESOURCE SECTOR	6.418771409143081
SECTOR PERFORMANCE INDICATOR FOR WELFARE SECTOR	6.892738285200763
SECTOR PERFORMANCE INDICATOR FOR MAINTENANCE SECTOR	6.619851063308327
SECTOR PERFORMANCE INDICATOR FOR MANAGEMENT SECTOR	7.177457986548995
TOTAL QUALITY MANAGEMENT INDICATOR	6.951317011367
BASE SCORE	9.214265805721
PERFORMANCE INDICATOR	7.403906770237

Continuous Improvement Effort Must Follow After Each Assessment..........

THANKS FOR USING TIS

Fig 8.6
The Output for PI of Garden-1



RESULTS OF ASSESSMENT

GARDEN INFORMATION	
NAME OF THE GARDEN	Garden-2
POST OFFICE	xxx
DISTRICT	xxx
PIN CODE	xxx
NAME OF THE COMPANY	xxx
AREA OF THE GARDEN IN HECTARE	1027.2
TOTAL PRODUCTION OF ALL TYPE OF TEA IN THE PERIOD (Kg)	735531
COMPUTING PERIOD	2003 TO 2004
AVERAGE PRICE REALIZED FOR ALL TYPE OF TEA IN AUCTION (RUPEES)	57.23
DATE OF COMPUTATION	6th April 2004
CODE OF COMPUTING AGENT	PK

RESULTS OF ASSESSMENT	
SECTOR PERFORMANCE INDICATOR FOR GARDEN SECTOR	5.236793450219876
SECTOR PERFORMANCE INDICATOR FOR PROCESSING SECTOR	5.319034557821950
SECTOR PERFORMANCE INDICATOR FOR ENERGY SECTOR	3.679345781004563
SECTOR PERFORMANCE INDICATOR FOR HUMAN RESOURCE SECTOR	5.869238013485570
SECTOR PERFORMANCE INDICATOR FOR WELFARE SECTOR	5.993478867502367
SECTOR PERFORMANCE INDICATOR FOR MAINTENANCE SECTOR	6.135793299560347
SECTOR PERFORMANCE INDICATOR FOR MANAGEMENT SECTOR	7.178905839508732
TOTAL QUALITY MANAGEMENT INDICATOR	5.649248974364
BASE SCORE	9.214265805721
PERFORMANCE INDICATOR	6.362252340635

Continuous Improvement Effort Must Follow After Each Assessment..........

THANKS FOR USING TIS

Fig 8.7
The Output for TQMI of Garden-2

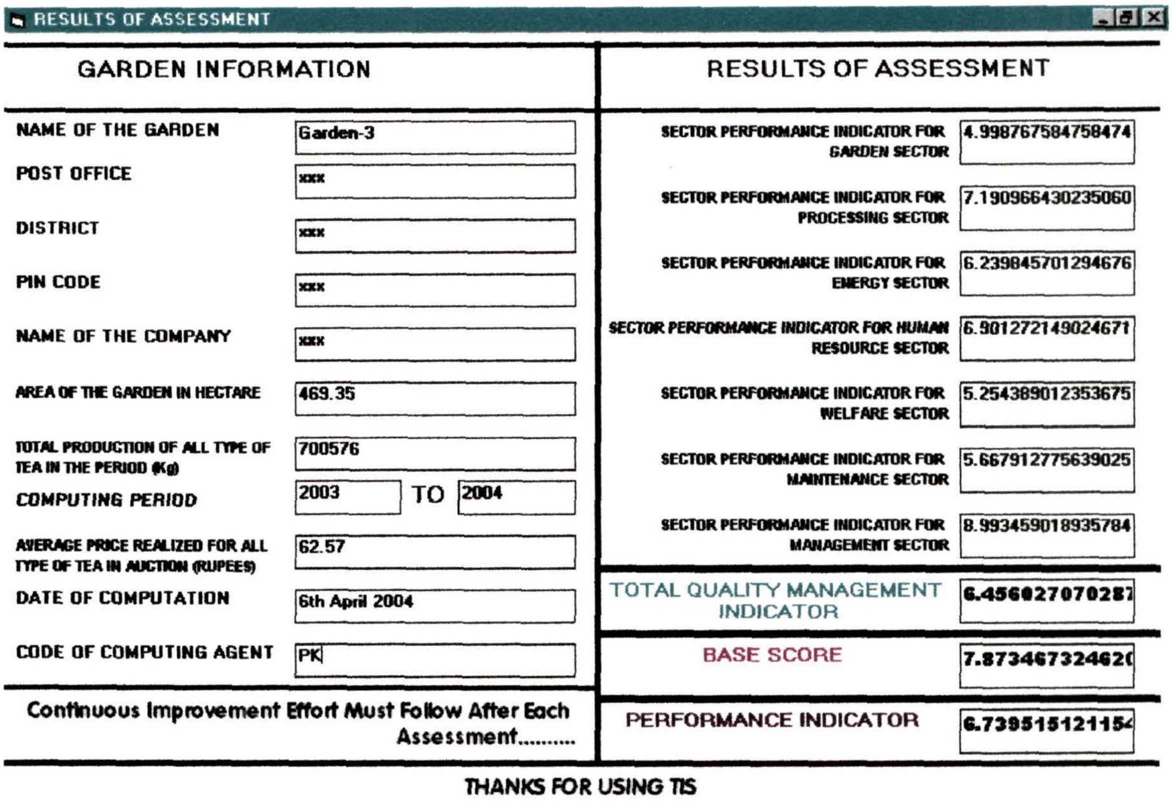


Fig 8.8
The Output for PI of Garden-3

8.7 TQMI and PI Vs. Average Price Realized in Auction by the Gardens

The computed values of the TQMI and PI along with the average price realized for all types of tea by the gardens in the computing period are given in Table 8.4.

Table 8.4
TQMI, PI and Price Realization of the Gardens Under Study

	TQMI	PI	Average Price Realized in Auction (Rs.)
Garden – 1	6.951	7.403	67.45
Garden – 2	5.649	6.362	57.23
Garden – 3	6.456	6.739	62.57

8.8 Discussion

8.8.1 Correlation Among TQMI, PI and Auction Price Realized of a Garden

TQMI and PI of a garden reveal the level of quality culture prevailing in the garden. The management controllable factors affecting the quality of made tea of a garden are included in the computation of TQMI and the management uncontrollable factors are included in the computation of PI of the garden. Though PI incorporates the factors which are uncontrollable in nature, the effect of some of these factors can be minimized through proper effort initiated by the management. Tea quality, if judged in terms of price realized in the auction market, tends to be higher with the increase of quantitative value of TQMI and PI. (Table 8.4)

However, more such analysis will be required to arrive at a general conclusion on the positive co-relation of TQMI, PI and price realized in auction.

8.8.2 TQMI and PI Assessment Group

A good number of factors in TQMI model are related to assessment of the existing management policy. The result may be erroneous and biased if these are assessed by the concerned Management of the garden. As such, it is proposed that: the TQMI and PI for a garden need to be assessed and computed by an independent body comprising of Tea experts, Tea consultants and Quality consultants. The Management of the Garden should assist the team by supplying genuine data of the garden for the period and reveal the common practices adopted by the garden in all the sectors. Feedback from the management level people as well as other employees and labourers would reveal the exact TQMI of the garden.

Chapter: IX

Development of An Information System for Tea Industry

9.1 Introduction

With the ever increasing utilization of Information Technology, no one can remain un-alarmed by its mind blowing benefits. And tea industry is not an exception. As described in earlier chapters, tea industry is one of the oldest industrial establishments of India. Starting from the steep hills of Darjeeling, through the green valleys and plains of Assam and up to the Nilgiri Hills, tea is one of the prime concerns to people's life in India.

Despite the great passion for tea round the world, it is quite disappointing to see that there is a lack of digital information about Assam Tea– both on-line & off-line. It is disheartening to see that there is no known informative software available. The very few commercial sites available on the net do not satisfy the thirst of a common man looking for information on the gigantic industry since they have a touch of self-interest. Even the people associated with the industry often find it difficult to cope with the ever-increasing demand of the fast growing industry due to lack of proper informative channels/sources.

Moreover, many tourists coming from all over the world who are passionate for "*Chai*" are very much interested in getting information about Tea - its cultivation, manufacturing and the culture associated with it.

This Chapter deals with the development of an Information System for Tea Industry of Assam incorporating all the possible aspects of tea. The information system has been linked with software for computation of TQMI and PI for a tea garden. The calculation of TQMI as described in the previous chapter involves lot of computation which if done manually, would be both time consuming and complex. The TQMI module developed as an executable programme (TQMI.exe) in Visual Basic environment deals exclusively with the computation of the TQMI and PI of a tea garden.

The objectives behind the development of the Information System are:

Primary Objectives:

- The Tea Information System would serve as a Knowledge-base for the Tea Management
- It would help the knowledge-seekers to know about the facts of Tea Industry

Secondary Objectives:

- It would act as an estimation tool for evaluation of TQMI of a garden.
- It would help Tea Management Professionals in decision making

In order to fulfill the requirements, the information system developed here, designated as "**TEA INFORMATION SYSTEM (TIS)**" can prove to be a starting step. The information system provides an in-depth coverage on Assam Tea Industry. It includes the origin of tea and tea facts, tea cultivation, tea manufacturing process, status of Assam tea, tea standards, factors affecting quality of tea with causality, culture of tea tribe of Assam etc. and computation of TQMI and PI of gardens.

9.2 The Structure

The Information System is menu driven, user friendly and elaborative in structure. It has been developed in a simple way. The information system is Window 98 Based, developed using MS Front Page providing hyper linking with VB 6.0. It occupies nearly 327 MB of memory space. The contents of the Information System is shown in Fig 9.1

The algorithm of the Tea Information System for user guidance is given in Appendix VI – A.

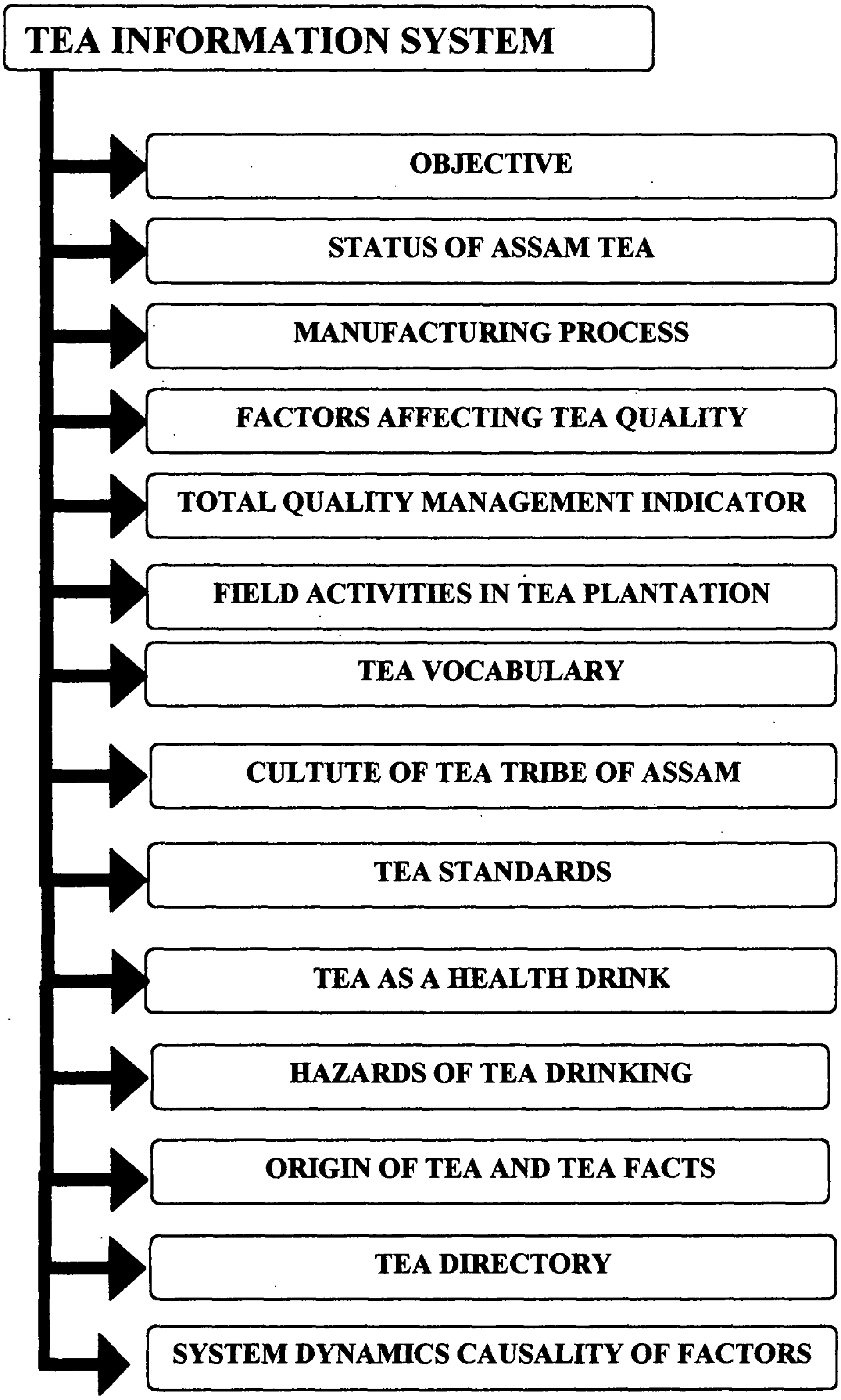


Figure 9.1
Contents of Tea Information System (TIS)

9.3 Menus and Screens of Tea Information System

The Tea Information System is a menu–driven information system developed in HTML and Visual Basic 6.0. The Information System consists of more than fifty screens. Some of the screens of the Tea Information System are shown below:

Fig 9.2a and Fig 9.2b show the Theme Screen and Start-Up Screen respectively of the Information System.

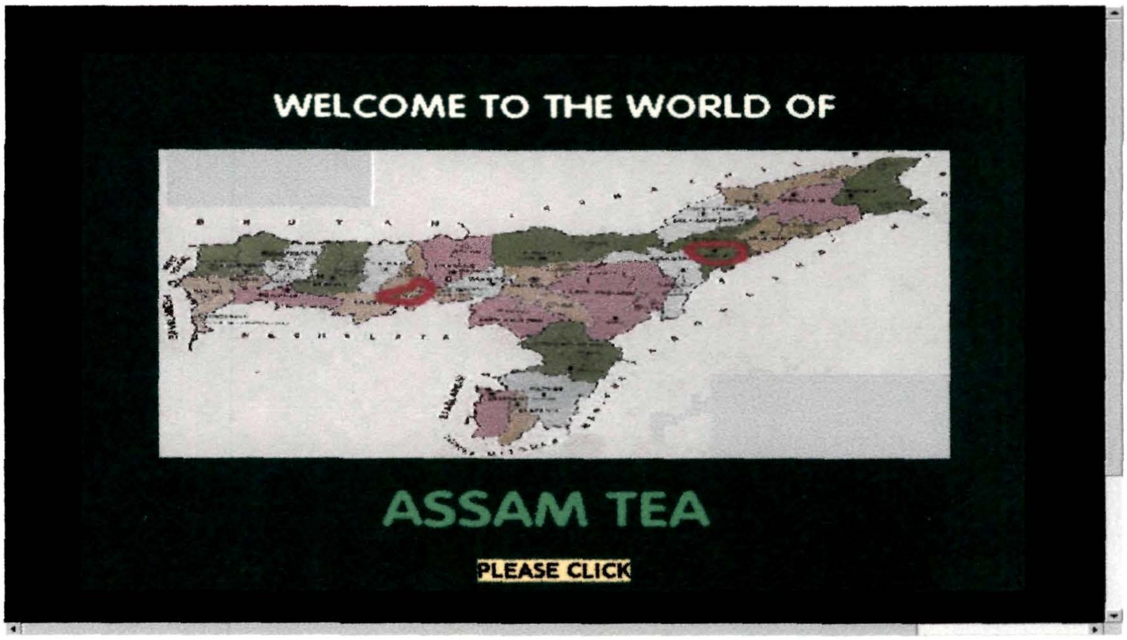


Fig 9.2a
The Theme Screen

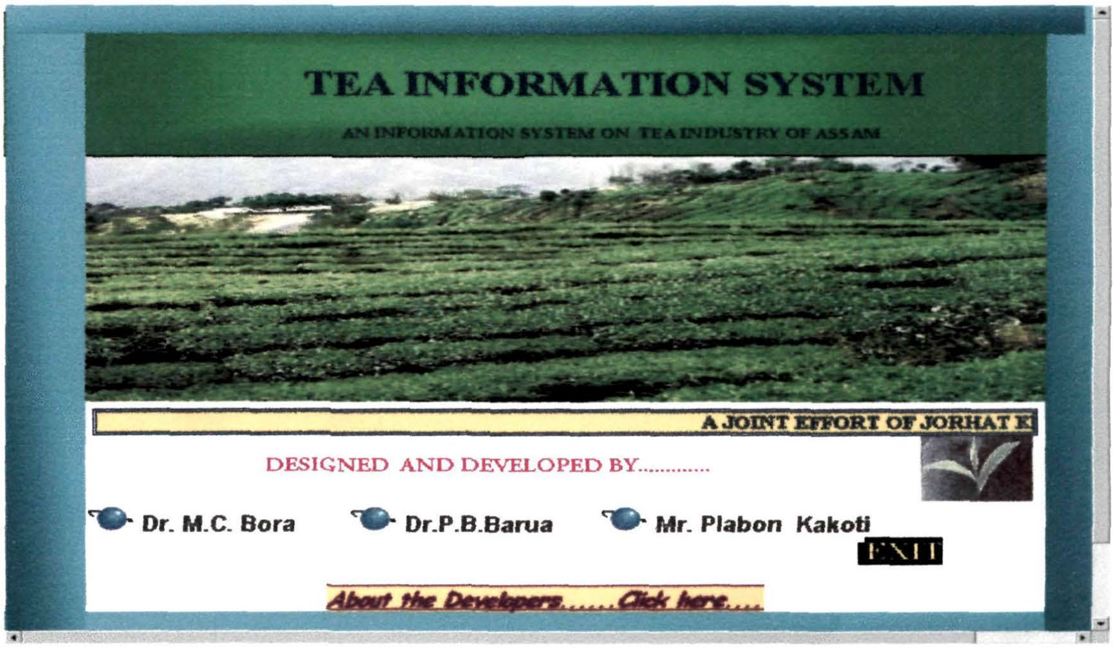


Fig 9.2b
The Start-up Screen

Fig 9.3 shows the Screen for Main Menu

Fig 9.3
The Main Menu

Fig 9.4 shows the Screen for Culture of Assam Tea Tribe Menu

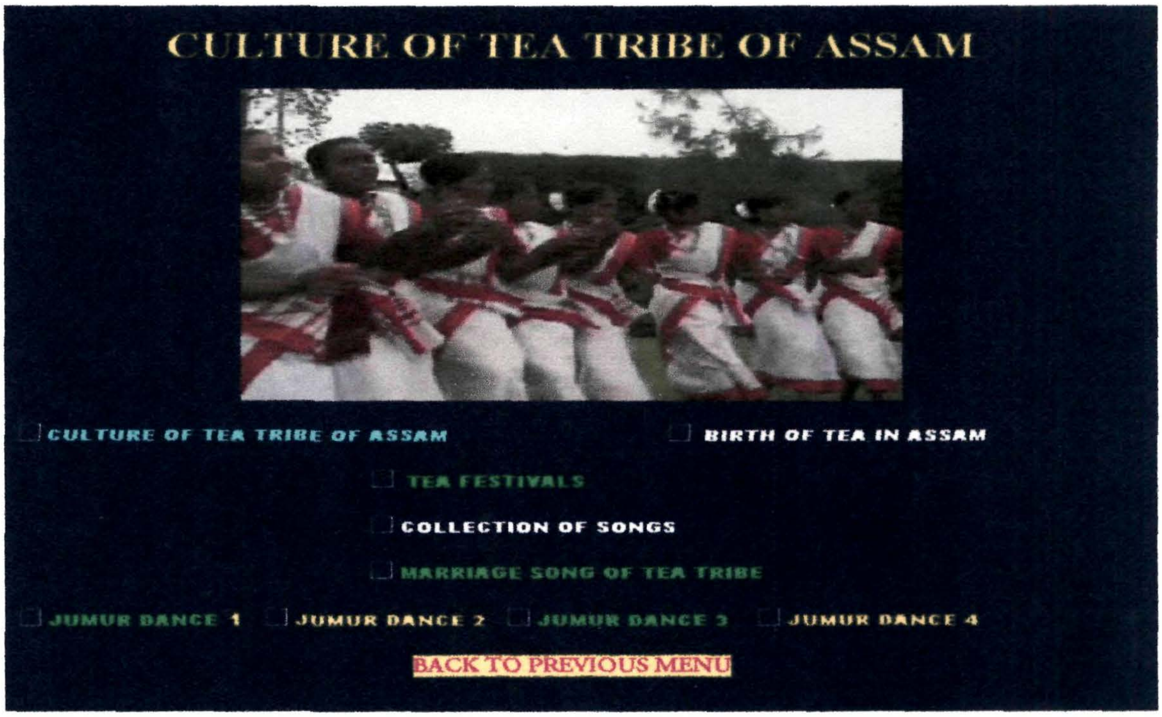


Fig 9.4
The Culture of Assam Tea Tribe Menu

Fig 9.5 shows the Screen for Processing Menu

Fig 9.5
The Processing Menu

Fig 9.6 shows the Screen for Origin and Tea Facts Menu

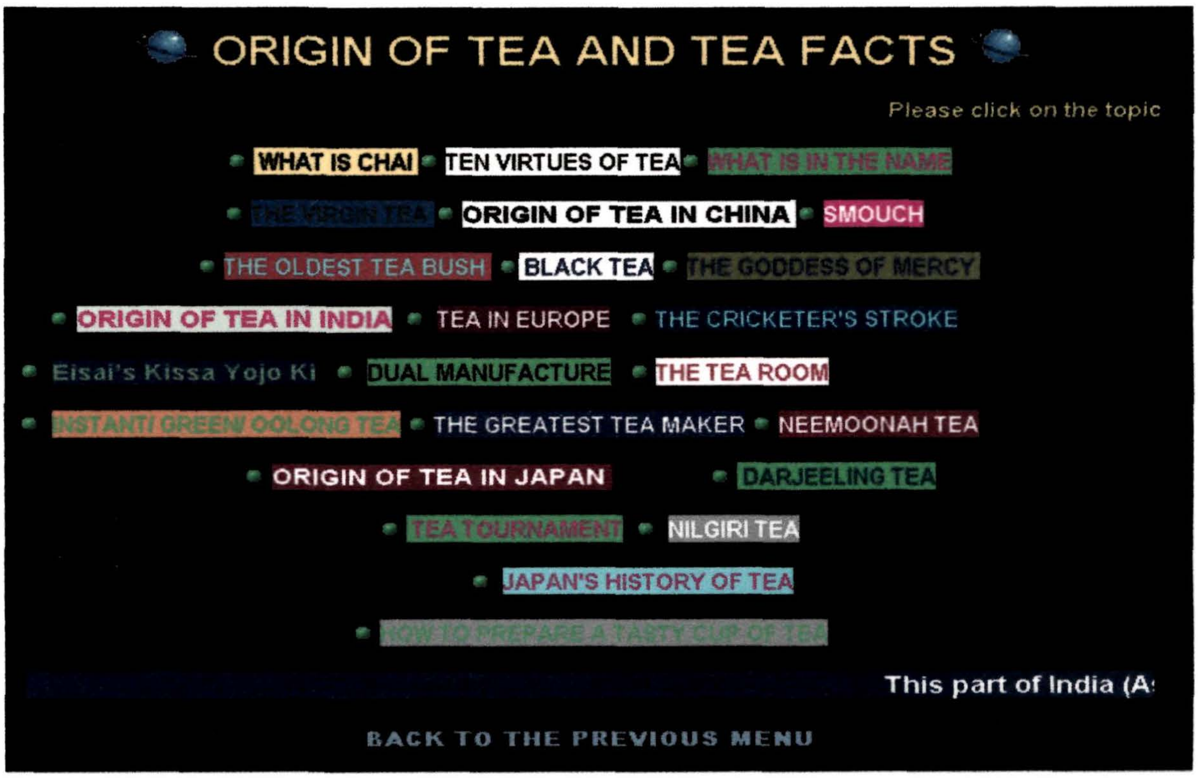


Fig 9.6
The Origin and Tea Facts Menu

Fig 9.7 shows the Screen for the 'Health Aspects of Tea Drinking' Menu

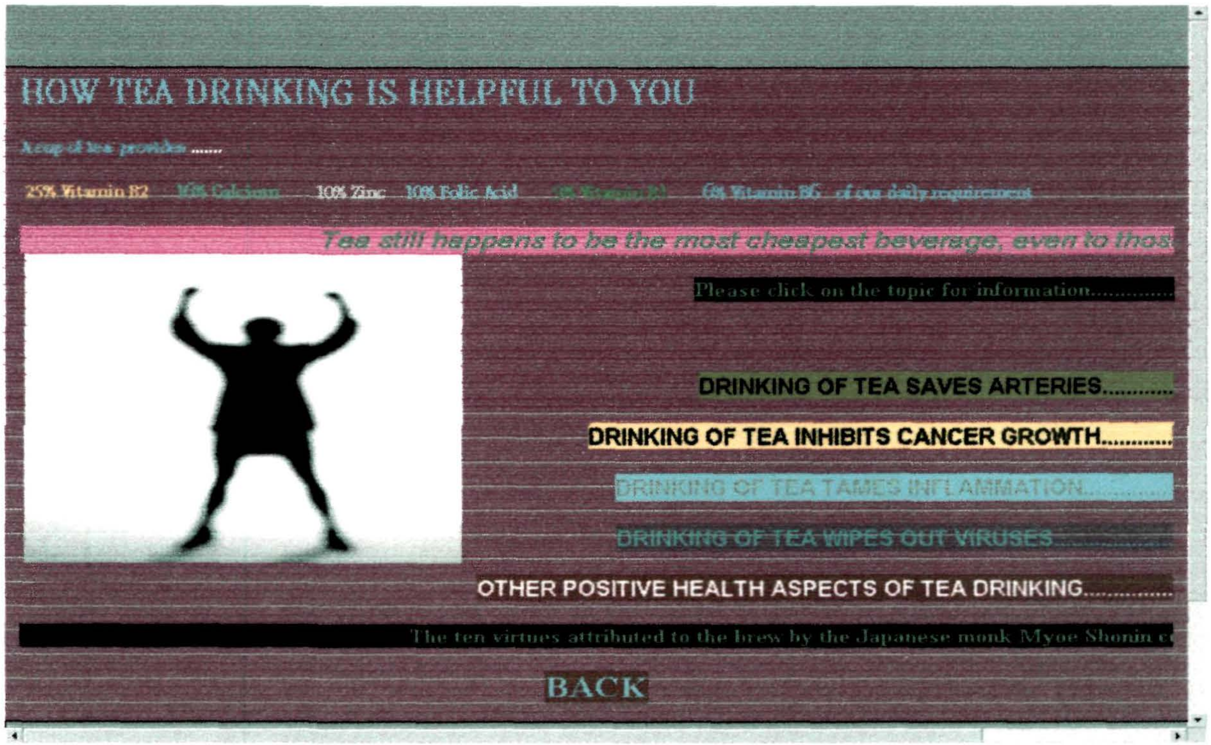


Fig 9.7
The Health Aspects of Tea Drinking Menu

Fig 9.8 shows the screen for the field activities menu

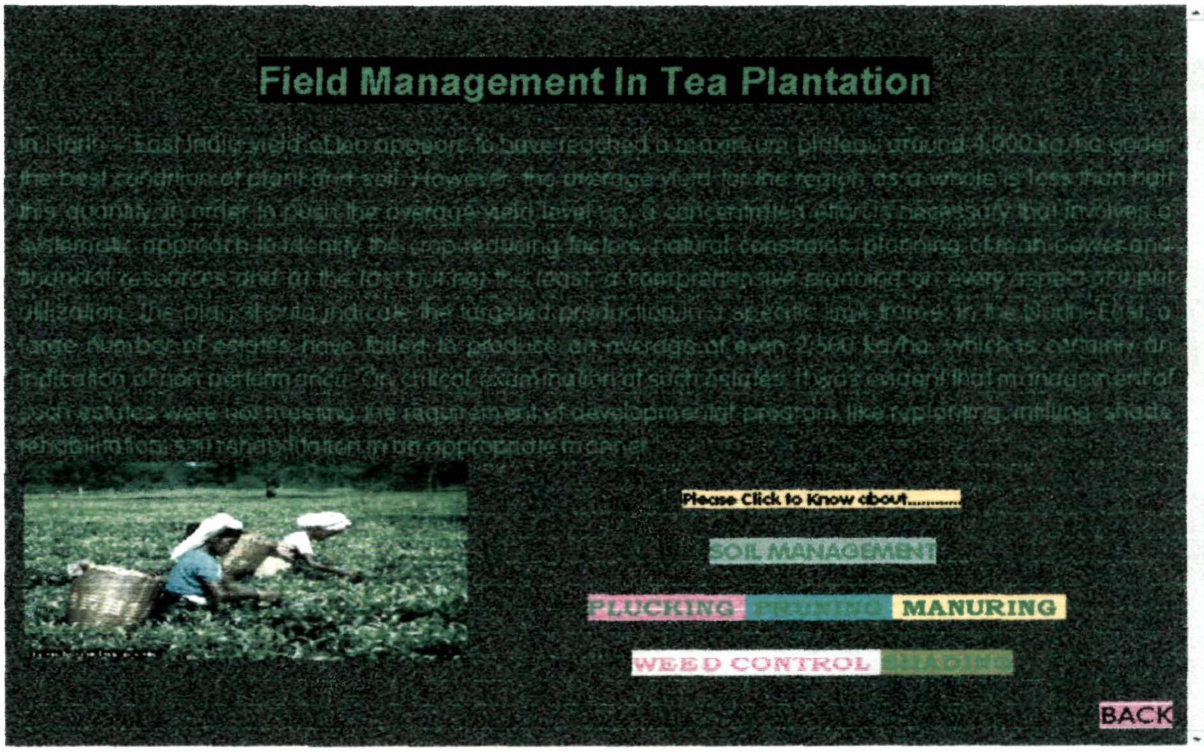


Fig 9.8
The Field Activities Menu

Fig 9.9 shows the Tea Standards Menu

Fig 9.9
The Tea Standards Menu

Fig 9.10 shows the Screen for the Tea Vocabulary Menu

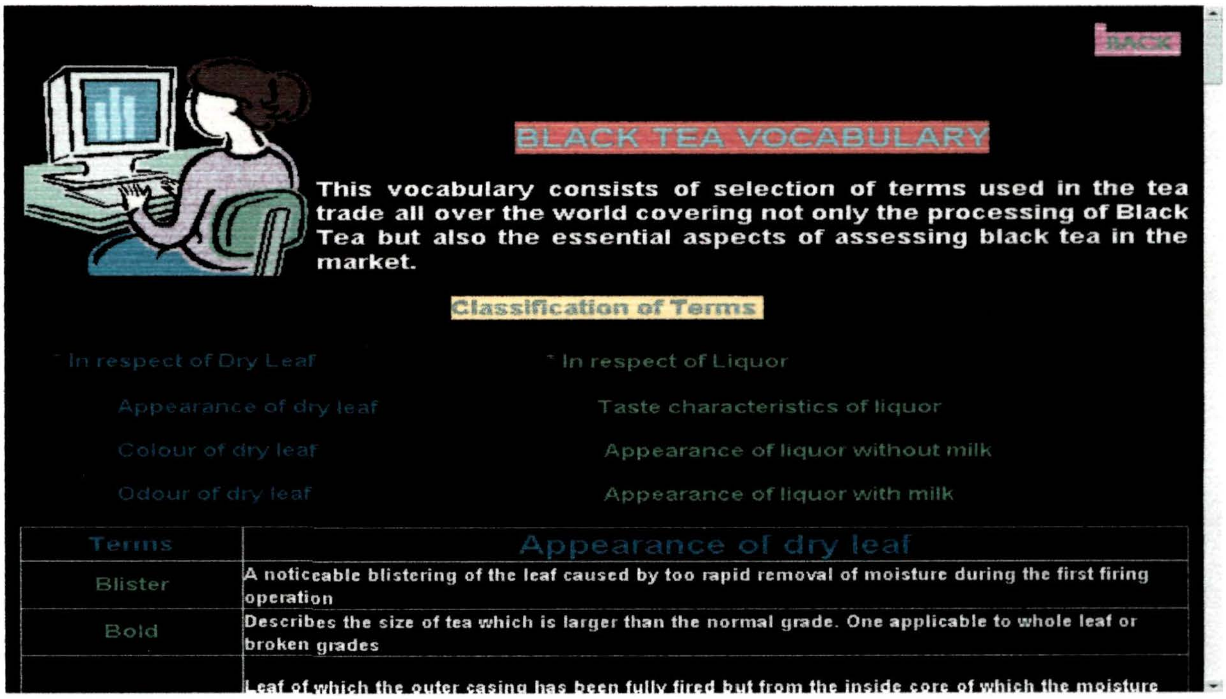


Fig 9.10
The Tea Vocabulary Menu

Fig 9.11 shows the Screen for TQMI Menu

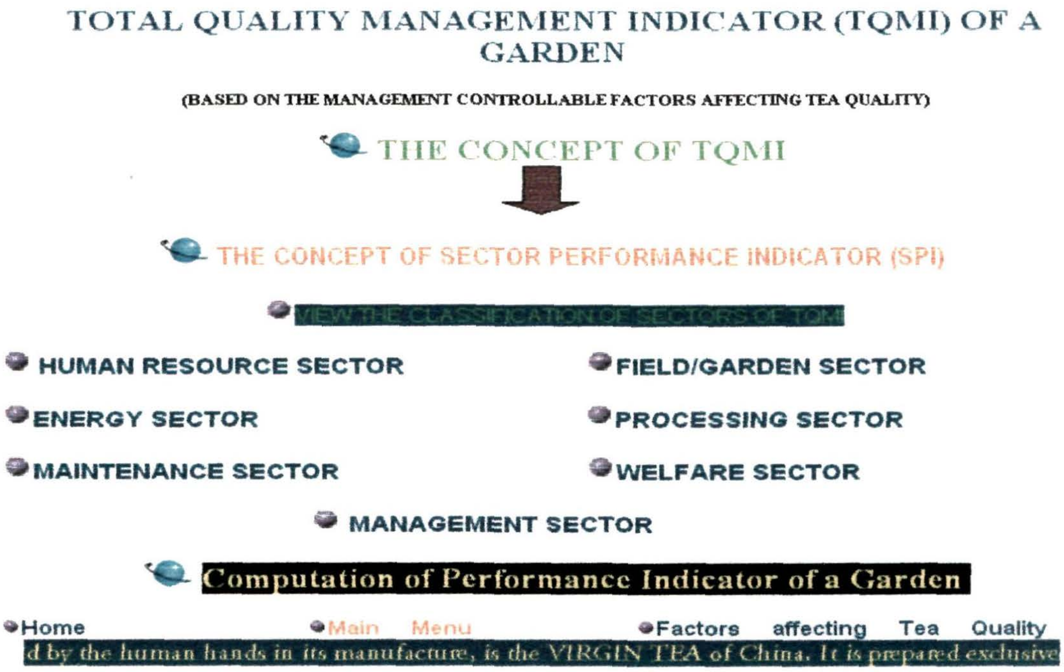


Fig 9.11
The TQMI Menu

Fig 9.12 shows the General Information Entry form for TQMI Computation

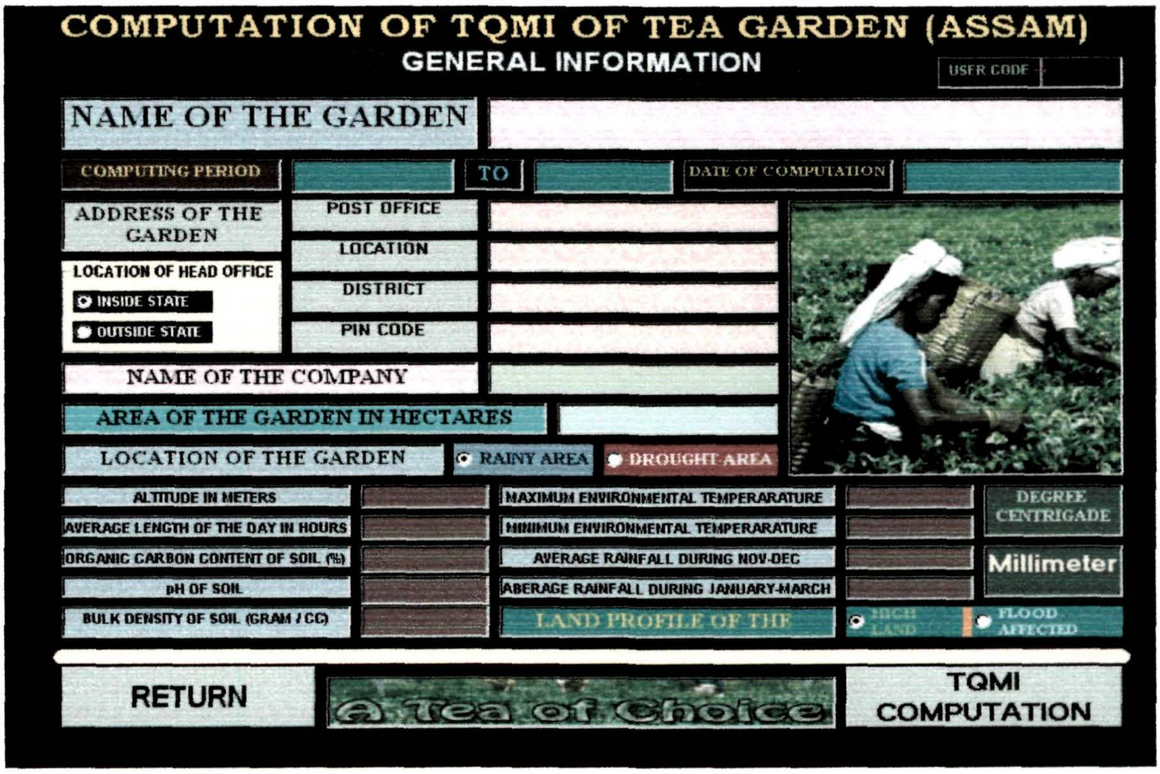


Fig 9.12
The General Information Form for TQMI Computation

Fig 9.13 shows the Attribute Information Entry Form for SPI for Garden Sector for TQMI Computation

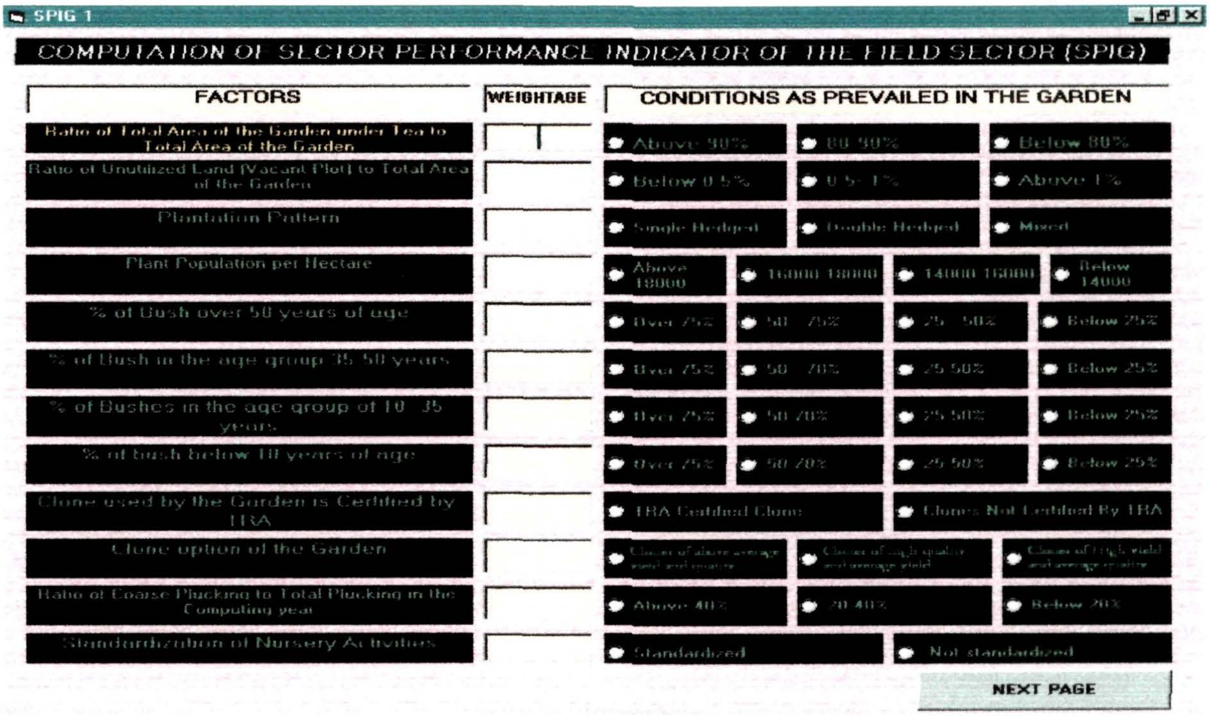


Fig 9.13
The Attribute Information Entry Form for TQMI Computation

Fig 9.14 shows the Final Result Form for TQMI Computation

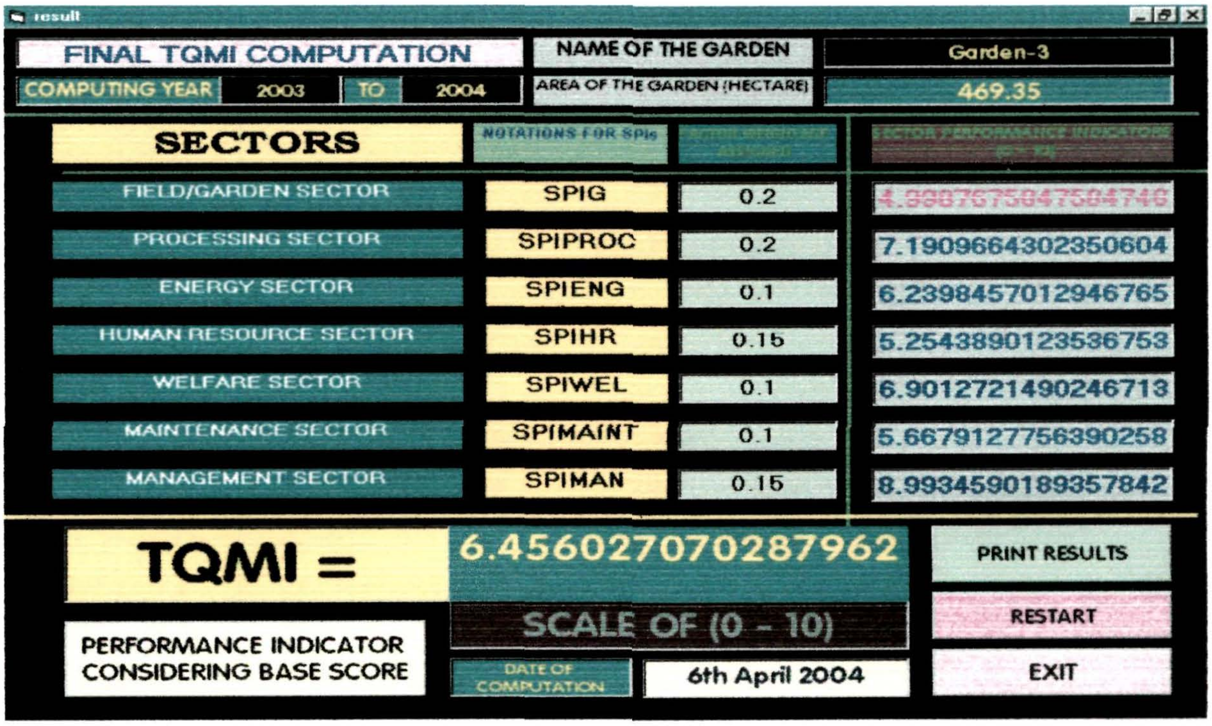


Fig 9.14
The Final Result Form for TQMI Computation

Fig 9.15 shows the Final Result Form for PI Computation

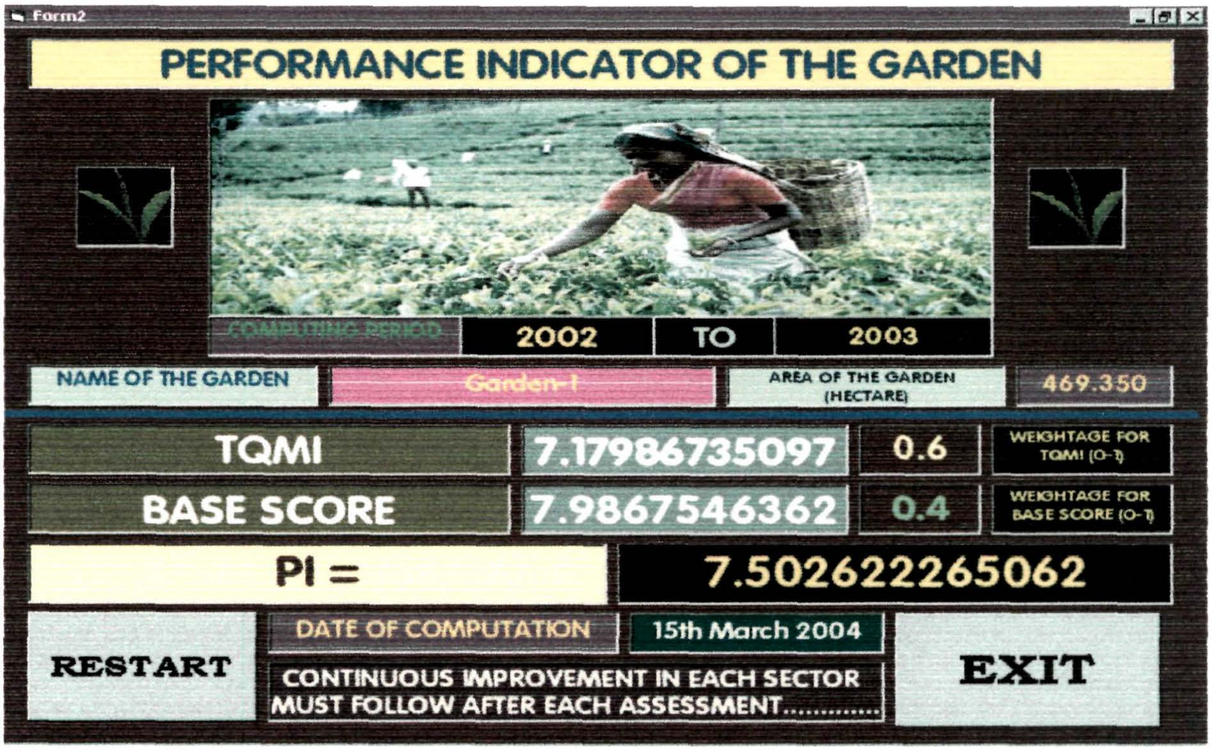


Fig 9.15
The Final Result Form for PI Computation

Fig 9.16 shows the Search Output of the Tea Directory

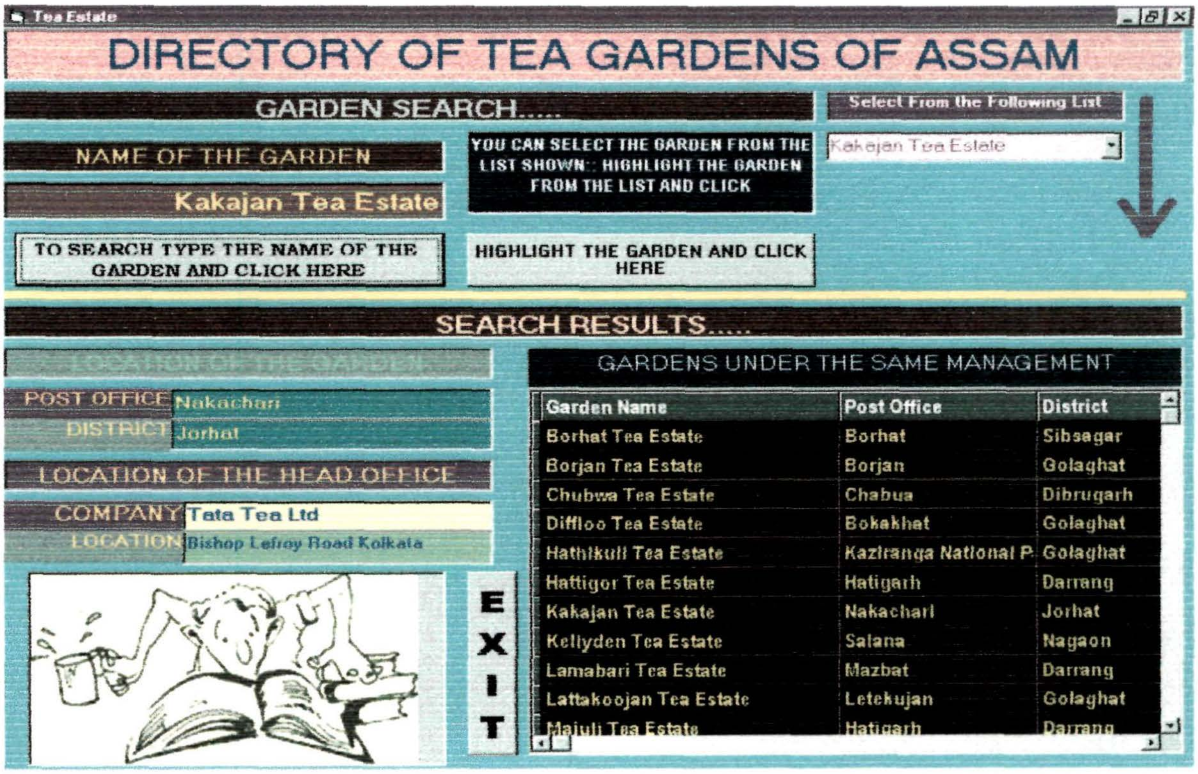


Fig 9.16
Search Results (Output) of Tea Directory

Fig 9.17 shows thc Format of Printcr Output of TQMI Computation

GARDEN INFORMATION		RESULTS OF ASSESSMENT	
NAME OF THE GARDEN		SECTOR PERFORMANCE INDICATOR FOR GARDEN SECTOR	
POST OFFICE		SECTOR PERFORMANCE INDICATOR FOR PROCESSING SECTOR	
DISTRICT		SECTOR PERFORMANCE INDICATOR FOR ENERGY SECTOR	
PIN CODE		SECTOR PERFORMANCE INDICATOR FOR HUMAN RESOURCE SECTOR	
NAME OF THE COMPANY		SECTOR PERFORMANCE INDICATOR FOR WELFARE SECTOR	
AREA OF THE GARDEN IN HECTATRE		SECTOR PERFORMANCE INDICATOR FOR MAINTENANCE SECTOR	
TOTAL PRODUCTION OF TEA FOR ALL TYPE OF TEA IN THE PERIOD (Kg)		SECTOR PERFORMANCE INDICATOR FOR MANAGEMENT SECTOR	
COMPUTING PERIOD	TO	TOTAL QUALITY MANAGEMENT INDICATOR	
AVERAGE PRICE REALIZED FOR ALL TYPE OF TEA IN AUCTION (RUPEES)			
DATE OF COMPUTATION			
CODE OF COMPUTING AGENT			
Continuous Improvement Effort Must Follow After Each Assessment..........		THANKS FOR USING TIS	

Fig 9.17
Printer Output Format of TQMI Computation

Fig 9.18 shows the Printer Output Format of TQMI, Base Score and PI Computation

GARDEN INFORMATION		RESULTS OF ASSESSMENT	
NAME OF THE GARDEN		SECTOR PERFORMANCE INDICATOR FOR GARDEN SECTOR	
POST OFFICE		SECTOR PERFORMANCE INDICATOR FOR PROCESSING SECTOR	
DISTRICT		SECTOR PERFORMANCE INDICATOR FOR ENERGY SECTOR	
PIN CODE		SECTOR PERFORMANCE INDICATOR FOR HUMAN RESOURCE SECTOR	
NAME OF THE COMPANY		SECTOR PERFORMANCE INDICATOR FOR WELFARE SECTOR	
AREA OF THE GARDEN IN HECTATRE		SECTOR PERFORMANCE INDICATOR FOR MAINTENANCE SECTOR	
TOTAL PRODUCTION OF ALL TYPE OF TEA IN THE PERIOD (Kg)		SECTOR PERFORMANCE INDICATOR FOR MANAGEMENT SECTOR	
COMPUTING PERIOD	TO	TOTAL QUALITY MANAGEMENT INDICATOR	
AVERAGE PRICE REALIZED FOR ALL TYPE OF TEA IN AUCTION (RUPEES)		BASE SCORE	
DATE OF COMPUTATION		PERFORMANCE INDICATOR	
CODE OF COMPUTING AGENT			
Continuous Improvement Effort Must Follow After Each Assessment..........			
THANKS FOR USING TIS			

Fig 9.18
Format of Printer Output of TQMI, BS and PI computation

For the other screens of the Information System the ***Compact Disk attached*** with this thesis may be referred.

9.5 Conclusion

The objective behind the development of the Tea Information System is to provide an in-depth coverage on Tea Industry and assessment of TQMI of a garden. It can serve as an MIS for tea management to be used as a decision tool.

It is hoped that the Tea Information System will be of great use to the Tea Industry. The system is designed in a user friendly manner. The Tea Directory and the Tea Vocabulary incorporated in the system will be useful for anyone seeking information on tea gardens and to know about the interesting terminology used in tea respectively.

The Information System can also be effectively used by tourism departments of various states of North-East India. It can be used as an interface between the tea industry and the common people.

The Tea Information System can be improved upon by providing information on the latest technological developments in the field taking place round the world so that any person associated with the industry can be benefited from it.

Chapter: X

Development of a Causal Model for Tea Garden

10.1 The Dynamics of Tea Quality

As discussed in the earlier Chapters, the output quality of a garden depends on a number of factors. A garden has to undertake diverse nature of activities such as plantation, plucking, processing, sorting etc. before sending the final made tea to the market. A number of factors affect each of these activities which in turn affect the quality of made tea.

The quality of the output (final made tea) depends on the quality of the service provided by different sub-systems (sectors). However, quality of the output of the sub-systems is also dependent on the funds available, which is again dependent on the revenue. The revenue is generated through sales of the made tea. The auction market generally decides the price which, in turn, is guided by quality. However, quality is judged by the attributes developed during processing. The attribute quality, theoretically is, directly proportional to the quality of each of the sub-systems identified.

Quality of tea is dependent on the interaction of quality raw material (tea leaves), process (the tea plantation, nurturing and manufacturing process) and men (managerial and labour). Tea gardens must have to explore the standards for better quality inputs to the tea manufacturing system.

Quality inputs in tea production leads to quality output, i.e., high quality marketable tea. In turn, the buyer of these outputs will also have high satisfaction. Customer satisfaction, on the other hand, enhances the reputation of the garden leading to enhanced credibility of the garden as well as increased sales volume. The satisfied top management i.e., the Head Quarters will be inspired to put more effort for enhancing the infrastructural and people welfare activities by providing more funds for such activities. As is evident in Fig 10.1, the entire system becomes a positive feedback loop, which is having a growth pattern, and TQM becomes the driver for growth.

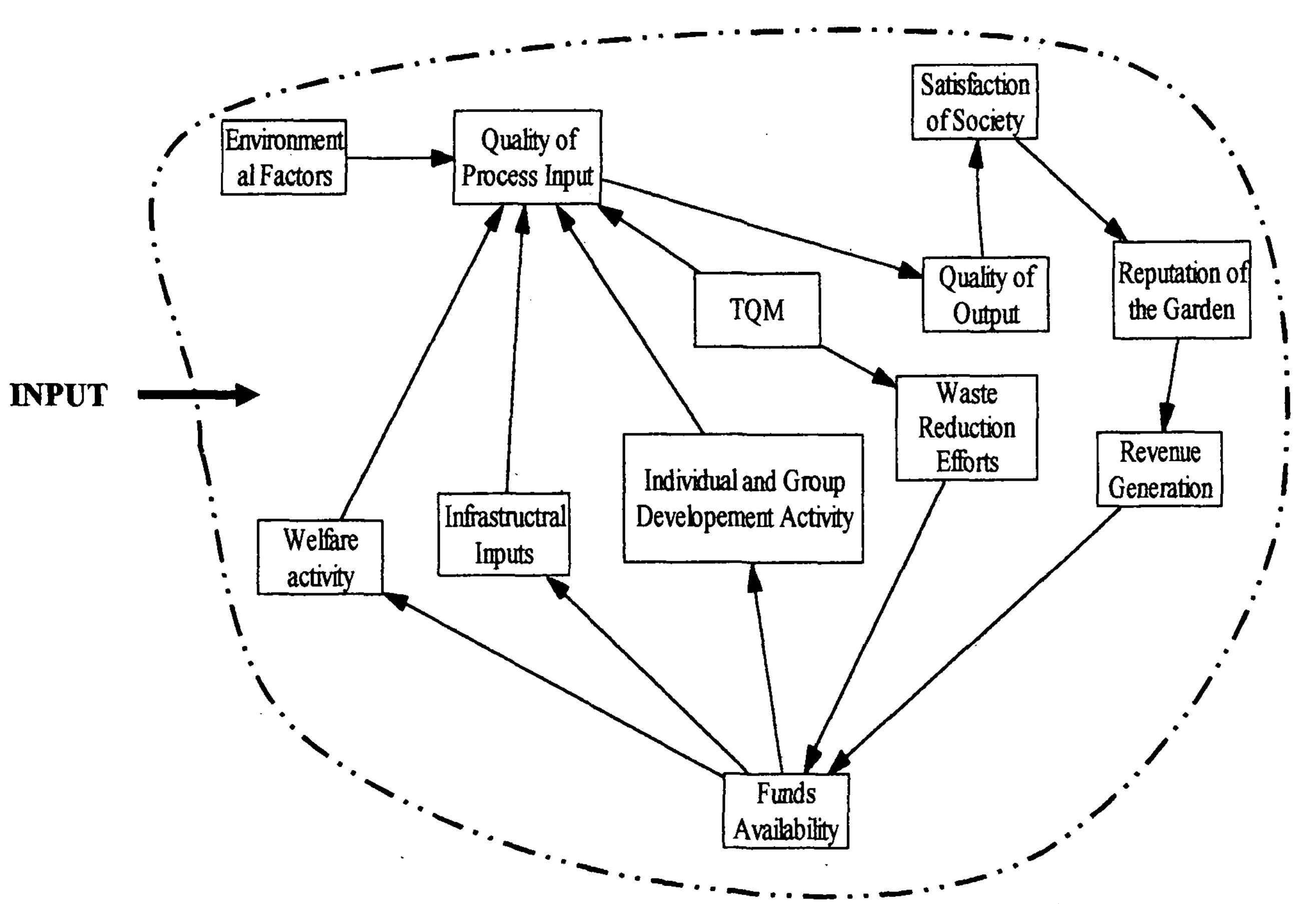


Fig10.1
The Dynamics of Tea Production System

Unlike simple systems, the causality of factors in a tea garden system is not direct. The involvement of lot of factors determining the tea quality of a garden with varied degree of dependency among them makes the system very complex in nature.

Management of a garden may be interested to see how the output of the system would vary with change in an input parameter. Moreover, for long term quality planning, it becomes quite essential for any management to know in advance, the possible behaviour for and sensitivity of the system to parameter changes.

System Dynamics (SD) enables to understand how scenario changes with time and gets stabilized in time. SD methodology makes it possible to understand how things change through time and how the system can be influenced through the change in policies and structure of the system.

SD is an approach, which takes a causal view of reality, and uses quantitative means to investigate the dynamic behaviour of socio-economic systems and their response to policy. Policy analysis helps to determine if certain behaviour modes persist in the face of different policies, and if certain policies are more affected by changes in the sensitive parameters, which form the basis for subsequent recommendation.

10.2 SD Causal Model Development for Tea Garden

As already discussed in Chapter VII while developing the TQMI model that Total Quality Management Indicator for Tea Gardens reflects quantitatively the quality of the different sub-systems (SPIs) comprising of tea production. One may define it as the interaction of the quality of the different management activities involved, such as plantation management, field management, production management, energy management, man management, welfare etc. All these activities directly or indirectly contribute to the quality of the product as conceptualized in TQM.

Total Quality Management Indicator (TQMI) is the result of two types of variables at the sector level – the attribute and the variable factors. The attribute factors represent mainly the standards and culture to be followed for all-round development of the garden, while the variable factors represent the cost aspects of the sectors. The first type is 'higher the better type' of factors and the later is mainly 'lower the better type' of factors. The TQMI is the resulting effect of interaction of both the type of factors. As TQMI of a garden improves, the quality of tea improves, resulting in more demand. Enhancement in demand finally results in increase in requirement of more tea leaves. In order to meet the increasing requirement, a garden has to compromise with standard practices for better tea. This results in a deviation from the standard practice of the garden for quality tea. The effect of this deviation may result in a transient growth of the garden but may not be sustainable at all. The driving force which may resist such a situation is the 'Quality Culture' prevailing in the garden and its commitment to quality.

This aspect of sustainable development of Tea Garden system is modeled in the proposed SD Causal Model. The related inter linkages of the factors affecting TQMI of a garden are depicted in the causal loop diagram (Fig 10.3). The variables used in the causal model for modeling various Sectors Performance Indicators are as described in Chapter VII (Equation 7.1 to 7.33).

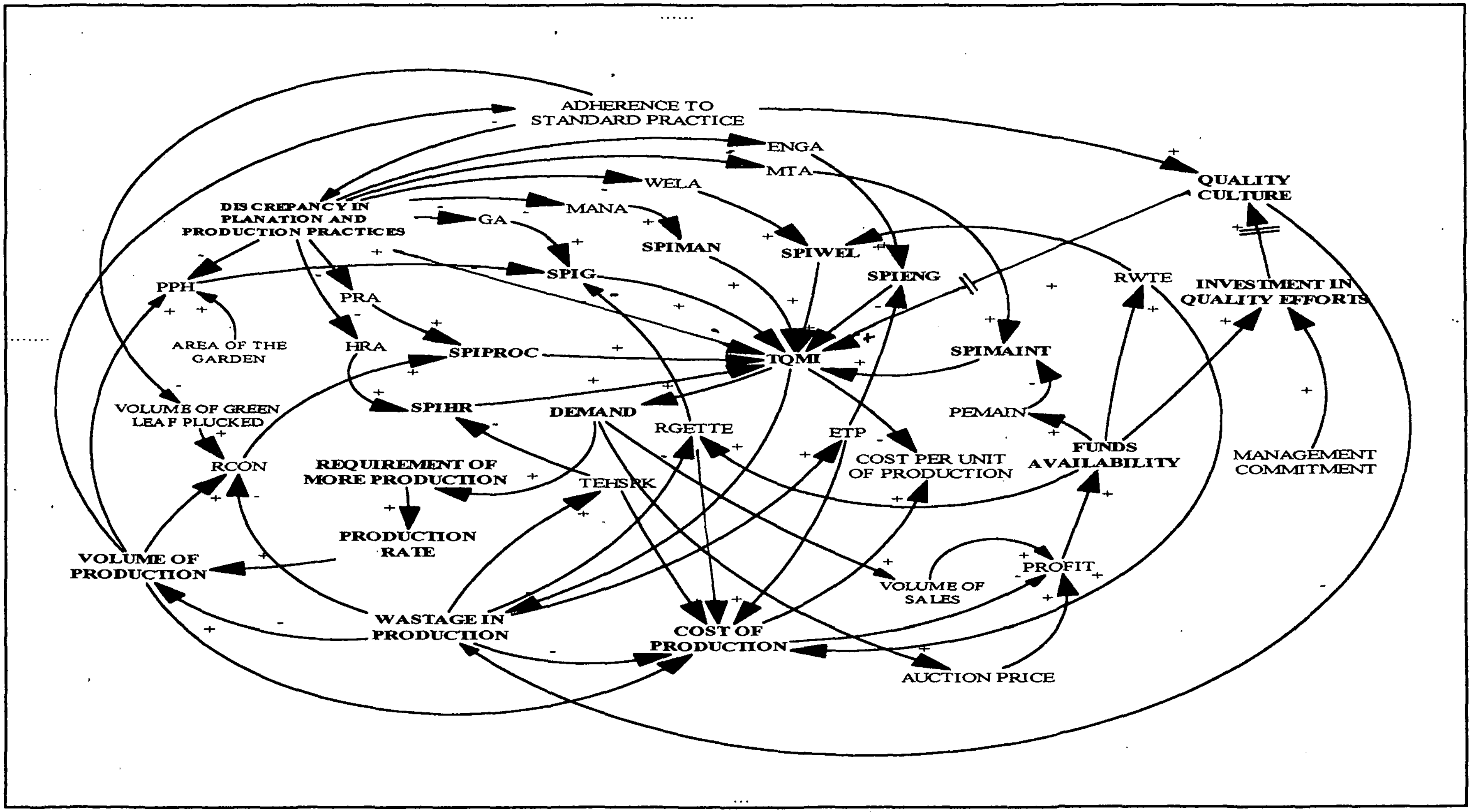


Fig: 10.2
SD Causal Diagram for Sustained Growth of Tea Garden System

The simplified SD causal diagram for the system is shown in Fig 10.3

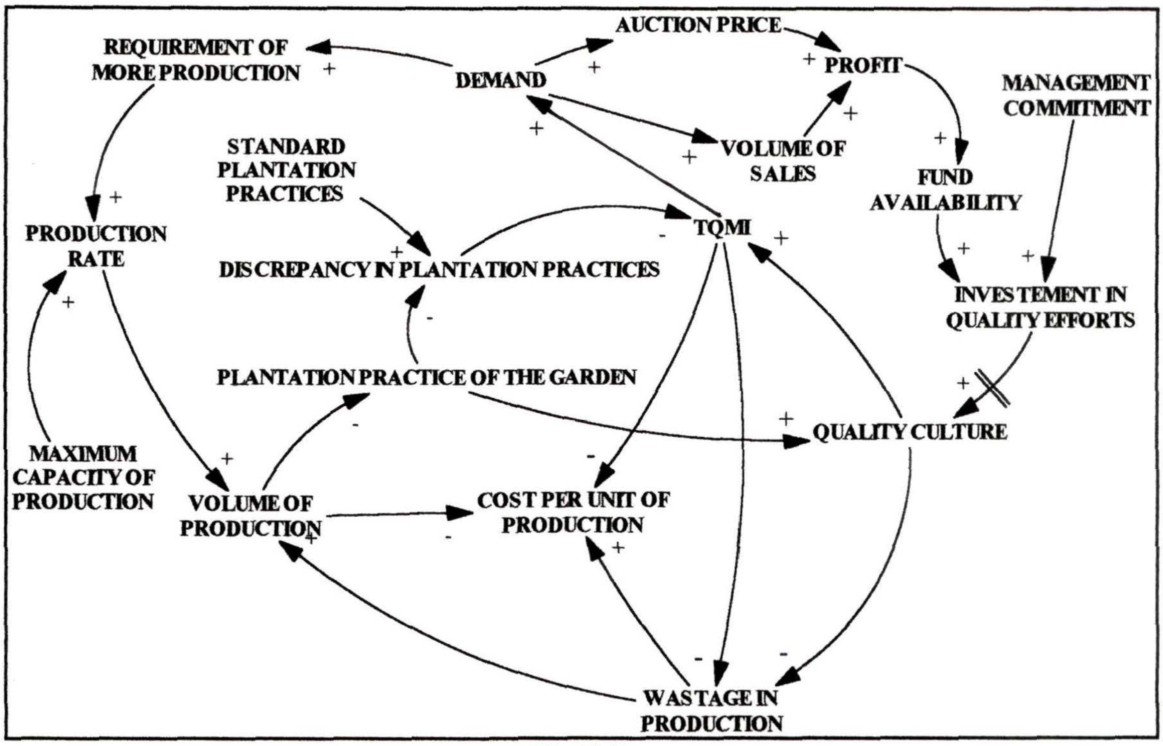


Fig10.3
Simplified Causal Loop Diagram for Sustained Growth of Tea Garden System

10.3 Loop and Qualitative Analysis

As presented in Fig 10.3, there are two major loops in the system. These loops are presented separately in Fig 10.4 and & Fig 10.5.

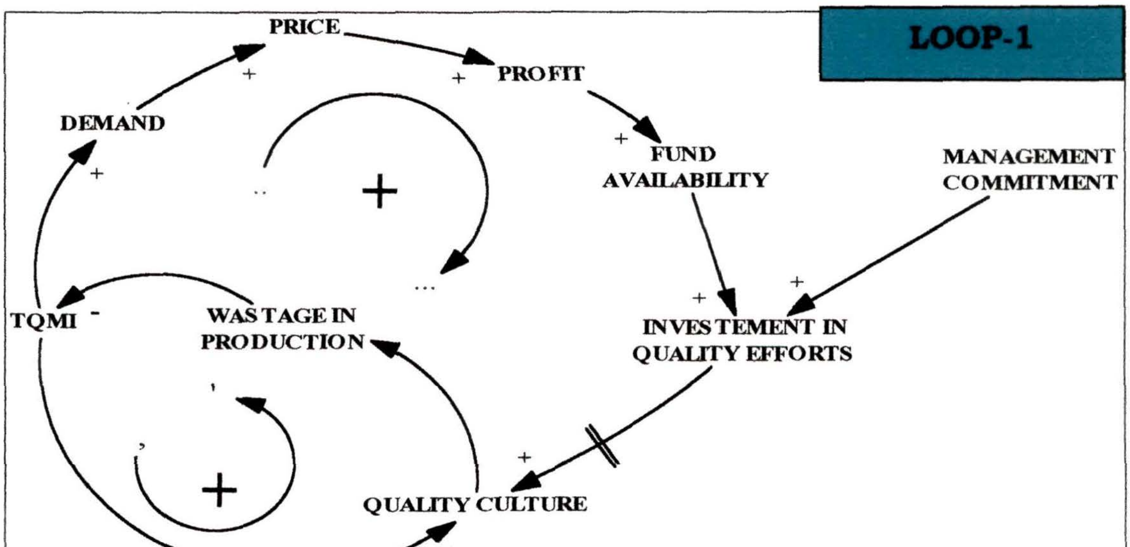


Fig 10.4
Loop 1 of the Causal Loop Diagram

10.3.1 Analysis of Loop-1

Increase in demand for tea of a garden result in increase in auction price and the volume of sales. This in turn gives rise to level of profit. Profit gives rise to availability of fund of the garden enabling the management to invest more in quality enhancement programs. This results in enhanced level of quality culture of the garden. This further result in reduction in wastage in different sectors of the garden. And finally the TQMI of the garden is affected in a positive manner resulting in better quality of output of the garden. This further creates more demand for tea produced by the garden in the market.

On the other hand, with the enhancement in the value of TQMI, the attribute factors are influenced creating higher level of quality culture of the garden.

Both the internal loops in Loop-1 are positive feedback loop. The positive feedback loops leads the variables to grow or to decay in an exponential manner.

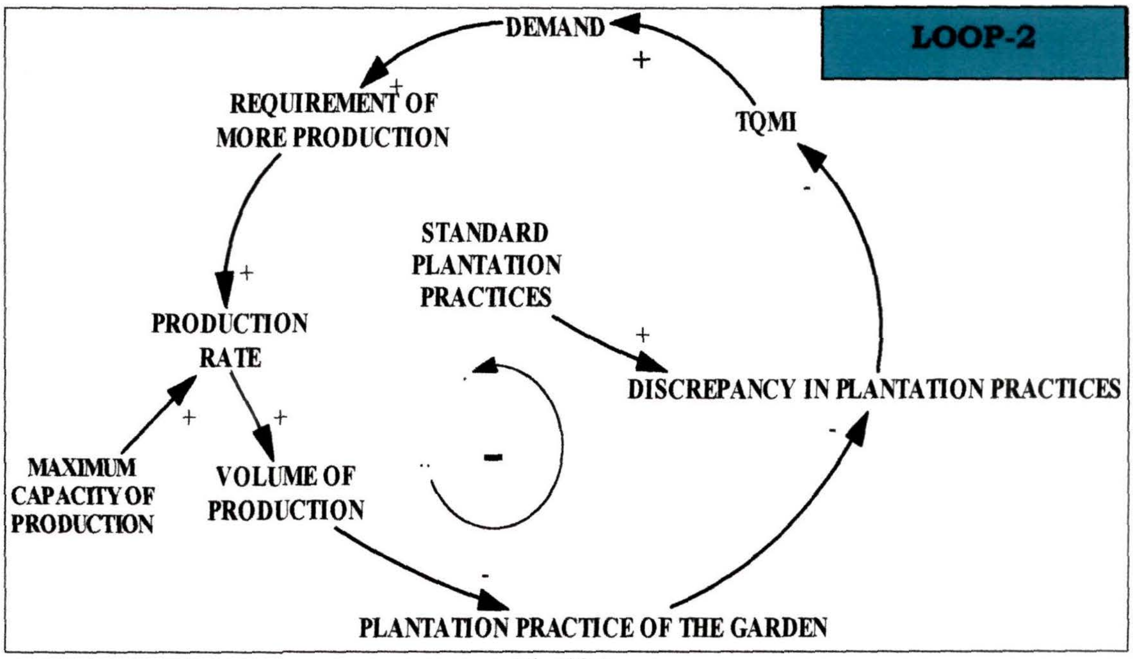


Fig 10.5
Loop 2 of the Causal Loop Diagram

10.3.2 Analysis of Loop-2

Increase in the value of TQMI of a garden gives rise to more demand for their tea in the market. With the increase in demand with time, a garden would try to fulfill the demand by going for more production. Naturally, constrained by availability of land and maximum production capacity, the garden would have to deviate from standards for producing quality tea (like going for coarse plucking, reduced processing time, least emphasis on inspection, employing more unqualified labour force, neglecting maintenance activities etc.) to meet the increased demand. This would lead to increase in volume of production with substandard quality of output. This would finally result in lowering the value of TQMI of a garden. This results in a negative feedback loop.

10.3.3 Overall Effect of the Loops

The overall effect of the two positive feedback loops of Fig 10.5 and the negative feedback loop of Fig 10.6 would result in different levels of TQMI of a garden with time. The system would behave dynamically due to interaction of the loops. This effect of deviation from plantation standards for increased level of production requirement would affect the stability of the system. The TQMI of the garden may take a growth or decay pattern. The growth pattern may be possible only when the garden adheres to standards for production of quality tea. This would be decided by the level of commitment for quality from all concerned within the garden. Development of a vibrant quality culture may be the only option for stabilization of the system in the long run and thus, sustenance of high TQMI of the garden.

10.4 Conclusion

This Chapter discusses the aggregate causal relationship of the major variables that have effect on TQMI of a garden. The causal links have been established on the basis of first hand information collected from the garden and the quality models reported in various literatures. The main thrust of the causality development has been on the impact of causality factors on ultimate quality of the product. The quality culture can be represented by means of quality culture level prevailing among all the categories of employees and the management commitment level towards quality production.

No attempt has been made in this thesis to develop the SD Flow Diagram and then to develop the mathematical model for simulating the system. These tasks are beyond the scope of this thesis and are recommended for future research work.

Chapter: XI

Summary and Scope for Future Work

11.1 Summary

At a time when the whole world is witnessing growth in almost every aspect of business, the Indian tea industry is facing the worst crisis ever. The price of tea has been falling over last few years. Indian market has been flooded with foreign tea that are available at a lower price. As a result the fund position throughout the industry has suffered a setback. Workers of many estates have not been paid their wages and other statutory dues for months; operations in some have stopped and some are virtually in a state of closure.

Presently, when the export of Indian tea has considerably come down and Indian market has been flooded with tea from other countries, the need of the hour for the Indian tea industry is to stress a lot on production of Quality tea for sustenance and growth. (Chapter I)

While searching for the root of the ultimate effect 'Quality of made tea', in this study eight factors (viz., Genetic Factors, Environmental Factors, Cultural Factors, Leaf treatment Factors, Factory Hygiene Factors, Maintenance Factors, Labour Factors, and Processing Factors) have been identified and their causal relationships analyzed. The management of a garden, by putting sincere effort can improve upon the controllable factors (viz., Cultural Factors, Leaf treatment Factors, Factory Hygiene Factors, Maintenance Factors, Labour Factors, and Processing Factors) and minimize the effects of uncontrollable factors (viz., Genetic Factors, Environmental Factors). (Chapter III and Chapter IV)

In order to find out the most potential areas of cost reduction in a tea garden, a PARETO Analysis has been done on expenditure aspects of a garden. The analysis reveals that combination of expenditures on the heads labour, welfare and energy contributes 89% of the total expenditures. The experimental analysis on the Energy sector has revealed that key process for optimization of energy consumption is the drying process and the loss of thermal energy is estimated to be very high (more than 66% of the total input thermal energy). What concerns more in gardens is the reluctance of the management to re-use the exhaust air from the drying process. (Chapter V)

The literature survey in association with opinion and Questionnaire survey reveals that the Tea Industry in Assam is a good candidate for initiation of TQM principles. The aspects that make Tea industry in Assam a good candidate for TQM implementation are: the employees of tea gardens have got close association with the garden, a major part of the garden employees (the labourers) can be motivated by initiating welfare programs, the belief that 'garden's progress is their progress', positive attitude of both the managerial and labour force and above all the congenial atmosphere of 'to be better of' prevails in the gardens. It has been deduced that a Tea Garden (system) involving number of sectors (subsystems) and other components (machinery, human resources, external components etc.) demands active participation of all the major units of the garden to meet the quality needs. (Chapter II, Chapter VI).

In the process of finding out the factors affecting Quality of Tea, the Tea Garden is considered as the 'system' and this system is segregated into seven different sub-systems (sectors) (viz., Human Resource sector, Processing sector, Maintenance sector, Management Sector , Energy sector, Field/Garden sector, Welfare sector) and the causality of the factors is studied. The 'Total Quality Management Indicator (TQMI)' and "Performance Indicator (PI)' of tea gardens developed are appraisal tools to ascertain the degree of total quality culture prevailing in a tea garden. The TQMI and PI would help the Tea Management in assessing the standing of a garden in terms of overall quality. TQMI assessment is to be treated as the 'starting point' for continuous improvement efforts by tea management. The computation also helps Tea Management in finding the weak areas (sub-systems) of the garden needing more attention for improvement (the SPIs will indicate these areas). TQMI and PI in subsequent uses after initialization of Continuous Improvement Efforts (CI), would help the Estate Management in assessing the degree of improvement achieved in SPIs/TQMI/PI. TQMI and PI may prove to be very useful in comparing performance of gardens under the same management for identifying the garden(s) and their sectors needing more attention. (Chapter VII)

The TQMI and PI, while analyzed for a set of three gardens shows positive co-relation with the price –realized in auction by the gardens. (Chapter VIII)

The "Tea Information System (TIS)", incorporates the TQMI and PI assessment software. This Information System has the applicability of using it as a knowledge-base providing the information on Assam and Indian Tea Industry, various processes of tea manufacturing, tea facts, different grades of tea, the information about the culture of tea tribes of Assam, tea vocabulary, standards in tea, a well covered tea directory.(Chapter IX)

The Systems Dynamics (SD) causal model incorporating the factors affecting TQMI of a garden has revealed that maximum effort from management on adherence to quality standards must be made for sustenance of higher TQMI of a garden. (Chapter X)

11.2 Specific Conclusions

11.2.1 Hindrances for TQM Initiation for Improving Performance of Tea Gardens

Feedbacks from tea estates management reveal that the performance of a tea garden has been an issue of grave concern for the tea industry for some time now. SPIs of the sectors may show stagnation if improvement measures are not taken seriously. In recent times, the changing economic scenario, the rising costs of production and uncertainty in price realization have brought about the issue of improved sector performance under brighter focus.

As per the feedback from the gardens under study the hindrances for initiating and implementing TQM in gardens for improving 'performance' by introducing a system linking remuneration to productivity and other performance determinants like discipline, attendance and qualitative parameters, can be classified under three heads:

1. **Structural Hindrance**
    - The tea industry has set traditions and "*Dasturs*" (habitual behaviour). The categorization of garden's work follows a trend set by the wage board's recommendation and bilateral agreements reached over last couple of decades
    - Growth opportunities for the garden labour force are limited
    - Promotion to higher grades i.e., Sirdars and Supervisors are largely based on seniority in service
    - Tea Management is bound by agreements with the unions to maintain the labour strengths at a certain level

2. **Price Realization Hindrance**

- Major part of the cost of production in the form of wages is determined by the Estate Regulation linking wages to inflation while prices of the end product of a Garden (i.e., made tea) is determined by the market forces of demand/supply and consumer preferences

3. **Growth Hindrance**

- As an effect of the previous two factors, it is neither possible for the estate management to introduce attractive rewards, nor to open up growth opportunities to motivate the work force outside the prevailing parameters

11.2.2 Proposed Counter-Active Measures

To counter-act the effects of these hindrances accompanied by the fact of rise in cost of production and uncertainty in price realization; the options identified are:

- Optimal Utilization of Resources: Labour, Land, and Equipment
- Declare 'war against wastage'
- Elimination of unproductive work for optimal use of manpower and energy

All these alternatives are presented point-wise in different heads as follows:

A. Field Operations

Land and Labour

- Increase yield from land using right clone applying right manure at right time and in the right way
- Increase productivity of plucking by increasing plucking yield of workers per day through effective planning

Requisites for Improved Plucking Practices

- Use of improved Plucking Aids : More effective and mechanized
- Use of alternative mode of carrying the basket while plucking (carrying plucking baskets on shoulder slows down plucking)

- Enhanced inspection on plucking as some leaves are un-plucked due to over-reach by the plucker
- Use of proper size of baskets as there is a tendency to slow down plucking when baskets are near full
- Keep height of the plants within permissible limit (use of right pruning cycle)

Planting Material

- Stress on R & D activities and continuous look for that 'wonder clone' which is high yielding and suitable for Geo-physical conditions of Assam with excellent quality in Cuppage and Liquor
- Improvised Drainage System in water logged areas with proper outlet
- Proper attention to Soil physiology (assessment of deficiency in soil)
- Use of effective Pesticides with proper evaluated MRL (Maximum Residual Level)
- Uprooting and Re-planting are to be taken up with high quality and high yielding planting material with closer spacing
- Increasing the bush population to the desired standard

Research and Development

- Research and development of Mechanized Harvesters
- Research for improved pruning equipment to enable the worker to prune with ease with less use of human energy and better standard of pruning
- Tea is a perishable commodity – research on design and development of carriage system for green leaf transportation to the factory would ensure its quality
- Development of cattle repellent in field- to keep cattle trespass at bay
- Development of Cheap type of fencing to reduce cost in garden sector
- Research on tea drying to minimize energy consumption and optimal drying

War against Wastage

- 15 minutes delay in reporting by a worker means- in a labour force consisting of 1000 workers results in a loss of 250 man hours : curb on absenteeism, stress on labour punctuality
- On an average a tea estate of Assam consists of at least 12% unproductive labour force due to age old practices on the estate and commitment to social obligation. Identifying and employing them in other productive work would minimize wastage in Human Resource Sector

Uproot and Rejuvenate the Aging Bushes in Time

- Keep proper calendar for rejuvenation and record of age of the bushes (Appendix IV-K). This would increase SPI of Garden Sector.

Improvement of Agricultural Practices

- Strict adherence to the standards of practices (Appendix IV) for Quality Tea at optimal cost.

Supervision of Work

- Enhanced effort on effective supervision in Garden and Processing sector would increase SPI for these two sectors

B. Manufacturing Operations

Improved Technology- Machinery

- Installation of Conveyors wherever applicable
- Use of Standard CTC Machines
- Use of Continuous Fermenting Machines
- Use of Fluidized Bed Dryers
- Use of Conveyors in Sorting System

On Line Process Control in Factories:

- Ensure on-line process control in terms of
  - ➢ Manpower utilization
  - ➢ Energy usage

- ➢ Monitoring quality of tea
- ➢ Batch Inspection Method : The only means of Quality control in most of the gardens is to find the fault, or correct the process after the damage has been done (Use of off-line quality control is essential)
- ➢ Packing Material: Use of standard packing material prevents quality deterioration in transit.

C. Human Resource

Value-based Education

- Stress on value of life and not on 'just to read and write'
- Stress on health, hygiene and sanitation

Awareness amongst the labour force can be achieved through education and counseling. It should be stressed that the workers be educated on the aspect of value of life. Counseling on health, hygiene and sanitation are very vital for a fit and productive labour force

Reduction of Alcoholism

Most of the workers, even female workers, are habituated to taking alcoholic drinks in an uncontrollable manner. It is the main reason of **absenteeism**, and **bad health** of workers. Drive against alcohol addiction would help the tea management in increasing the labour productivity.

Eradication of Other Avocation

Many workers in the tea gardens also indulge in gambling, theft of green tea leaf or made tea, lottery, etc. NGOs or Social organizations may help the management in eradicating such evil practices by workers.

Improved Health Care and Medical Facilities

Most of the Tea Estates of Assam are complying with the statutory requirements for labour Welfare. In spite of all this the death rate, sick absenteeism etc. among the labour community are still very high. Health awareness drives from management would definitely enhance the SPI for the Welfare and Human Resource Sectors.

Improved Quality of Life

- Improvement in respect of Housing, Water supply, line sanitation, electricity, health care, labour clubs and playgrounds. (SPI for Welfare Sector has got direct bearing with these activities)

This aspect has a bearing on the geographical location of the garden. In Tea gardens in close proximity to towns and industrial belt, the workers, especially the males view a plucking job to be one without dignity and want to work only in factory or give "Badli" (Substitute) and look for alternative employment outside the estate.

Wages:– Daily Rated

In spite of the Plantation provisions of fringe benefits e.g., ration, free housing, firewood, tea, protective clothing, etc., workers only value the cash money received in hand and fail to attach importance to perquisites. They do not attach importance to the fringe benefits, as these are given practically free of cost. A change in the present wage system (daily rated) is essential. However, this is a very sensitive issue and needs careful approach in this direction.

Employment of Casual Labourers

No Garden can run without the Casual Workers for harvesting and factory work. Permanent Male Workers dislike Night Shift in Factory. In certain estates the permanent labour force goes slow on plucking to force the management to employ casual workers. Gardens must think to curb this phenomenon.

D. Motivational Imperatives

Modification of Incentive Scheme

- The present scheme of providing an additional 27 paise for each Kg of green leaf plucked over the standard pluck is ineffective.

- Implementing group incentive scheme where Sirdar/Supervisors get reward in cash or kind for the performance of his 'Chalan' (allotted job) suggested.

Include Fringe Benefits in Wage

Clubbing fringe benefits with wage would make the pay package attractive and appealing as workers are motivated only by the cash received in hand and they do not attach importance to the fringe benefit.

Promotion to Higher Grades

Should be linked to productivity and not merely on seniority

Counseling of Workers

Form Garden specific Quality Circles involving voluntary participation of Sirdards, garden and factory labourers (both permanent and casual), hospital employees, drivers, antigens, electricians, supervisors etc. The concept of participative management must be nurtured through these quality circles for better SPIs for Human Resource and Management Sectors.

Continuous on-job training programs for workers are essential to maintain an able work force.

Training programs on both job and human aspects for managers and supervisors are necessary.

Grouping of Performers: High/Low

Initially low performers and high performers should be grouped separately and rewarded on their performance suitably. Instill the spirit of competition among the groups so that the low performers would try to reach the level of the high performers and the high performers would always try to be ahead of the followers.

11.3 Scope for Future Work

The present work on TQM application in Tea Industry is limited to the Tea industry in Assam only for its homogeneity in regards to culture, topography and other environmental factors. The study aimed at finding the basis of TQM implementation in tea gardens of Assam. However, the study does not focus on procedural implementation of it.

The study has got the following scopes for extension:

1. While developing the model for quality of tea, the factors within the garden system have only been considered in this work. The factors beyond the garden like the distribution system of the tea dispatched from the garden, the auction related factors, the retail market factors etc. are treated as exogenous factors in this study. However, they do affect the demand for tea. The model for factors affecting quality of made tea can be extended beyond the garden to include these aspects.
2. On the aspect of wastes in tea plantation and processing, this study is limited to energy sector, peripheral analysis in processing sector (factory layout) and maintenance sector only. More detailed experimental analysis of wastes in all the sectors may be carried out separately
3. The TQMI/PI model covers seven sectors within the Tea garden system. TQMI/PI model may be extended beyond the garden considering all the exogenous variables as described in (1) above.
4. The universal applicability of TQMI/PI model is possible only when there evolves a consensus on common scores and weightages agreed by all the companies having gardens in Assam. The study can be extended for evolution of this consensus for using the TQMI/PI model for inter-garden performance evaluation.
5. The SD causal model developed in this thesis is aggregative in nature. Development of the SD Flow Diagram and the mathematical model for policy simulation would make it more effective for long term policy planning.

6. This thesis deals with the identification of the factors contributing to quality of made tea at the garden level, identification of management controllable factors,

development of a measure for assessment of standing of a tea garden in terms of total quality culture, assess the applicability of TQM culture in tea industry. The development of procedural implementation schedule of TQM in a garden after assessment of TQMI and PI has not been covered in this study. There exits a scope to extend the study on this aspect.

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Appendices

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Appendix- IA
The Questionnaire for collection of data for the TQMI Model
Appendix – IA: Letter accompanying the Questionnaire

IMPLEMENTING TOTAL QUALITY MANAGEMENT IN TEA INDUSTRIES
(A Research Project under Tezpur University, Tezpur, Assam)

Dr. Madhab. C. Bora	Dr. P.B.Barua	Plabon Kakoti
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To

Mr.

___________Tea Estate

Sub : Request to fill/answer the Questionnaire attached

Sir,

In the present business scenario, as a consequent of globalization and liberalized economy, the commitment of all concerned towards Quality and a vibrant Quality Culture are a must for survival of any business. Due to this current trend, most of the Corporate Houses are putting special impetus towards generation of Quality Awareness among the employees of the house and to enlighten them with the recent concepts of Quality and Total Quality Management (TQM) with the sole objective of implementing the philosophy of Total Quality Management (TQM) in the organization.

As a part of Industry-Institute interaction and to make a detailed survey of the possibilities of cost reduction in Tea processing by identifying and controlling the factors affecting the quality of made tea, a project work has been undertaken by Tezpur University, Tezpur, Assam.

To start with, a Questionnaire Survey among the managerial level people of your garden has been initiated. We feel and realize the scarcity of 'time' for a person involved in this profession, but at the same time we do not have any alternative other than involving you people in this work. Hope you would spare some of your valuable time to help us for successful completion of the work.

The 'Questionnaire' designed to develop a general model on the existing scenario of the proposed work.

In this connection we would like to assure you that your identity in the questionnaire would be kept unpublished. The information so generated will be solely used for academic purposes and to develop the general model only.

We believe that at this hour of recession of Tea sector in the market, successful completion of this project will evolve some fruitful results beneficial to tea industries. We sincerely believe that you would take part in the process religiously to make the research effort successful. Seeking your valuable co-operation in future too

Thanking you

Yours sincerely;

(Plabon Kakoti)

Any correspondence may kindly be addressed to:
Mr. Plabon Kakoti
Lecturer
Jorhat Engineering College, Jorhat – 785 007, Assam

Appendix – IB: The Questionnaire

IMPLEMENTING TOTAL QUALITY MANAGEMENT IN TEA INDUSTRIES
(A Research Project under Tezpur University, Tezpur, Assam)

Questionnaire

- **You need not write your Name, the name of the Garden etc.**
- **This is purely an academic effort for the betterment of Tea Industry of Assam**
- **Please provide data for the last season**

Please fill both the parts: Part I and Part II

PART I

I-A

Description	**Unit**	**Please specify**
Total Available area of the Garden	Hectare	
% area under cultivation (area under bush)	%	
Total production of tea of the garden in the last year	Kg	
Average Price Realized in Auction in the last year	Rupees	
Total Expenditure of the Garden in the last year	Rupees	
% of Total Expenses on Salary, Wage etc. for Employees in the last year	%	
% of Total Expenses on Maintenance of Factory, Building, Roads and other infra-structure in the last year	%	
% of total expenses in field activities in the last year	%	
% of total expenses on Energy (Diesel, TD oil, Electricity, Gas etc.) in the last year	%	
% of total Expenses under welfare head in the last year	%	
Net Present Value (NPV) of the Machines and Equipment in Factory (approximately)	Rupees	

I-B

FACTORS	Conditions As Prevailed in the Garden (Please Tick the Nearest Option)		
Average length of the day (Hour)	< 12.0 hours	12.0 – 12.5 hours	> 12.5 hours
Average rainfall during November – December (mm)	< 50	50 to 60	> 60
Average rainfall during January - March (mm)	< 70	70 - 80	> 80

Maximum environmental temperature (°C)	>40	35 to 40	< 35		
Minimum environmental temperature (°C)	< - 2	-2 to 4	> 4		
Organic Carbon Content of Soil (%)	Below 0.6	0.61 – 1.00	> 1.00		
Location of the Garden	Rainy Area	Drought Area			
Location of the Head Office of the Garden	Within the State	Outside the State			
Soil pH	Below 4.5	4.5 – 5.5	> 5.6		
Soil Bulk Density (Gram / cc)	<1.20	1.21 to 1.40	1.41 to 1.60	1.61 to1.70	> 1.70
Land profile of the Garden	High Land	Flood Affected Area			

PART II

Factors	Conditions As Prevailed in the Garden (Please Tick the Nearest Option)			
Ratio of Total Area of the Garden Under Tea to the Total Area of the Garden	Above 90%	80 – 90%	Below 80%	
Ratio of Area of Unutilized Land to the Total Area of the Garden	Below 0.5%	0.5 -1.0%	Above 1%	
Type of Plantation	Single Hedged	Double Hedged	Mixed	
Plant Population per Hectare	Above 18000	16000-18000	14000-16000	Below 14000
Ratio of Number of Bushes Over 50 Years of Age to Total Number of Bushes	Over 75%	50% - 75%	25%- 50%	Below 25%
Ratio of Number of Bushes from 35 to 50 years of Age to Total Number of Bushes	Over 75%	50%- 75%	25% - 50%	Below 25%
Ratio of Number of Bushes from 10 to 35 years of Age to Total Number of Bushes	Over 75%	50%- 75%	25%-50%	Below 25%
Ratio of Bushes of Age Less than 10 Years to Total Number of Bushes	Over 75%	50%- 75%	25%-50%	Below 25%
Clones Used by the Garden	TRA Certified	Clones not certified by TRA		
Garden's Option for Clones	Clones of Above Average Yield and Quality	Clones of High Quality and Average Yield	Clones of high Yield and Average Quality	
Ratio of Coarse to Total Plucking of the Garden in the Computing Period	Above 40%	20-40%	Below 20%	
Nursery Activities of the Garden	TRA Standardized	Not Standardized		
Frequency of Soil Testing for Primary and Secondary Deficiencies in Nutrients	Done before Plantation and Repeated Periodically	Done Before Plantation Only	No provision of Soil Testing	
Effect Analysis of Plant Rearing in Nursery	Done by Cause and effect analysis	Not Analyzed		
Determination of Spacing in Plantation	Determined on the Basis of Bush Character and Soil Condition	Traditionally or Arbitrary Determined		

In Single Hedge Plantation, Spacing Maintained is Nearly Equal to (cm)	90 x 60	100 x 60	105 x 60	105 x 65	105 x 75
In Double Hedge Plantation, Spacing Maintained is Nearly Equal to (cm)	105 x 70 x 75	110 x 70 x 70	110x 75x 75	110 x 70 x 65	110 x 70 x 60

Techniques used for Weed control	Hand Weeding	Hand Weeding for Collar Region with Herbicides for Remainder

Frequency of Inspection for Mites Attack, Insect Damage, Diseases for Young Bushes	Weekly	Fortnightly	Monthly	Bi-monthly

Basis of Assessment of Prune Parameters	Thorough 100% Inspection of the Garden	Sampling Inspection for Assessment	Not Assessed, Traditional

Policy on Bed of Prune	Always parallel to Ground, No Deviation Allowed	Roughness in the Bed Allowed

P and K is Regulation in Pruning	Every Time, After Assessing the Soil Condition	Occasional	Not Regulated

Pruning Cycle Adopted by the Garden	3 Years Cycle	4 Years Cycle
Normal Period of Pruning for Matured Tea Adopted by the Garden	December to Mid January	Any Other Convenient Time for the Garden
Normal Period of Pruning Young Tea Adopted by the Garden	End January to Early February	Any Other Convenient Time for the Garden

Basis of Adoption of Pruning Cycle of the Garden	Research Based	Experienced Based	Traditional

Plucking Standard Followed by the Garden	Fine Plucking	Coarse Plucking
Size of the Leaf Carrying Basket Used by the Pluckers	Standardized by TRA (55 x 55 x 55) cm	Standard Baskets not Used

Maximum Capacity of the Basket	Below 10 kg	10 - 15 Kg	15- 20 Kg	More than 20Kg
The Designed Capacity of Leaf Carrying Frame	Below 100 Kg	100 -120 kg	120 - 140 kg	More than 140 kg

Level of Care Taken Against Tight Packing of the Leaves in the Basket	High Care Under Strict Supervision	Occasionally when Quality Tea Required	Never Stressed
Inspection of Plucked Leaves for Contamination with Sand and Soil	Always Done	Occasionally Done	No Inspection for Contamination

Average Time Between Plucking and Withering	< 30 Min	30 Min - 1 Hour	1-2 Hours	More than 2 Hours

Basis of Selection of Temporary, Semi-Permanent, and Permanent Shading Trees in the Garden	TRA Standardized Trees	Arbitrary, Not Standardized Trees
Basis of Spacing Between the Shading Trees	TRA Standardized	Arbitrary, Not Standardized
Disease Control Programme of the Garden	Includes the Shade Trees Also	Does not Include the Shade Trees
Record of Pest Application	Stressed a Lot and Referred Before Next Application	Not Stressed Much and Not Referred Before Next Application
Grade and Quantity of Fertilizers used by the Garden	As Per Recommendation of TRA	As Per Experience of the Garden

Weed Control Outside the Tea Area	Done Periodically and is Considered As an Important Activity of the Garden	Not Undertaken Periodically : Least Stressed			
Use of Protective Clothing in Pest Application	Consistent, Used in Every Application	Not Consistent			
Measures for Fungus Attack of the Bushes	Done as per Recommendation of TRA	Done arbitrarily			
Inspection for Over and Under Spraying of Pesticides	Done After Each Application	Not Done Every Time	Not Done At All		
Basis of Uprooting Programme of Bushes	Survey of Yield	Survey of Vacancy	Survey of both Yield and Vacancy	Survey of Quality	
Basis of Priority in Uprooting	Sections Yielding < 65% of the Production	Sections > 25 % Vacancy	Sections Yielding Low Quality Tea	Arbitrary	
Existence of Estate Rejuvenation Calendar	Exists and Result oriented	Exists but Result not Assessed	Does not Exist		
Basis of Selection of Rejuvenation Activities	Tea with Poor Frames	Tea with Poor Frames and Good Collar	Arbitrary		
The Pattern of Yield for Last Five Years of the Garden	Increasing Trend	Constant Trend	Decreasing Trend		
Type of Manure Used	Organic	Inorganic			
Pesticides, Weedicides, Manure Testing for Assessing Ingredients	Tested by Qualified Tester After each Purchase Before Application	Tested by Qualified Tester Once in a Season	No Testing Done		
pH of Soil (Before Treatment)	Below 4.5	4.5- 5.5	Above 5.5		
Pre-Treated Soil Bulk Density (g/cc)	<1.20	1.21-1.40	1.41-1.60	1.61-1.70	Above 1.71
Calibration of Measuring Equipment Used in the Factory	Calibrated Periodically	Not Calibrated Periodically			
Inspection to Assess Leaf Damage Before Withering	Inspected Every time	Inspected When Quality Tea Required	Not Inspected At All		
Cleaning of Withering Trough Before Placing the Green Leaves on it	Cleaned Thoroughly Every Time	Cleaned Thoroughly but Sometimes Ignored	Periodical Cleaning is Done Only		
Thickness of Spread in Withering Trough	Standardized	Not Standardized, Arbitrary			
Normal Period of Withering	<12 hours	> 12 but < 16 hours	> 16 hours		
Consistency in Maintaining the Period of Withering	Very Much consistent	Variation Exists			
Adoption Of Humidity Control Measures In Withering	Adopted	Not adopted			
Targeted Temperature of Hot Air Maintained during Withering	<30° C	> 30° C	Not Measured At All		
Inspection Of Withered Leaf For Assessment of Withering before Putting to Rolling Operation	Rigorous Inspection, every time	Occasional Inspection	No Inspection		
Mode of Transport of Withered Leaf to the Rolling Machine	Manual	Conveyor			

Level of Care Taken Against Leaf Rupture in Transportation from Withering Trough to Rolling Table	High Care, Occasionally When Quality Tea Required	Very High Care, Always	Inconsistent/ No Proper Care Taken
Cleaning of CTC/Rolling Machines before Putting the Withered Leaves	Cleaned Thoroughly Every Time	Periodical Cleaning	
Assessment Of "Degree Of Wither"	Properly Assessed and is Used as an input to Decide the Rolling Parameters	Not Assessed/ Not Properly Assessed	
Provision for Continuous Monitoring of Rolling Pressure	Exists and Continuously Monitored Every Time	Exists But No Continuous Monitoring Every Time	No Provision of Monitoring
Provision for Continuous Monitoring of Rolling Temperature	Exists And Continuously Monitored Every Time	Exists But No Continuous Monitoring Every Time	No Provision of Monitoring
The CTC Cutter Tooth	Standardized	Not Standardized	
Humidity Control Measure in the Rolling Process	Exists	No Provision	
Inspection for Bacteria Attack in Rolled Tea	Done Every Time	Occasionally Done	Not Done At All
Assessment of Rolling	Assessed Every Time	Assessed Occasionally	Not Assessed At All
Type of Fermentation Used	Floor	Floor and Rack	Continuous Fermenting Machines
Cleanliness of Fermenting Floors/Troughs/Machines	Cleaned Thoroughly Every Time	Cleaned Periodically	Not Stressed Much
Testing of Floors etc. before Fermenting for Bacteria Formation	Done every Time	Done Occasionally	Not Done At All
Thickness of Spread in Fermentation	Standardized and Monitored	Standardized but Occasional Monitoring	Not Standardized/ Traditional
Humidity Control Measures in Fermentation	Exists	Exists, No Monitoring	No Humidity Control Measure
Fermentation Temperature	Standardized	Not Standardized	
Fermenting Time is Standardized as per the Type of Leaf	Yes	No	
Ventilation of Fermenting Roll	Well Ventilated	Poor Ventilation	
Assessment of Fermentation	Using Visual Assessment and Nose Test	Using Colour Sensors	
Test of Tea Leaves after Fermentation for Detection of Contamination	Done	Not Done	
Cleaning of Drying Trays Before Drying Process	Cleaned Thoroughly Every Time	Cleaned Periodically	
Type Of Dryer Used	ECP	FBD	VFBD
Monitoring of Drying Temperature	Constantly Monitored	Casually Monitored	
Thickness of Spread in the Drying Trays	Standardized, Followed Strictly	Standardized, Not Followed Every Time	Not Standardized
Standard for Thickness of Spread for Different Air Flow Rate and Size of Leaves	Spread of Thickness Varies Accordingly	Thickness of Spread Not A Function of These Parameters	

Assessment of Case Hardening and Wetness of Dried Tea	Done Every Time on Sampling Basis	Not Assessed/ Occasional Assessment			
Assessment of Moisture Content in Dried Tea	Done Every Time	Occasionally Done	No Provision of Such Assessment		
Type of Fibre Extraction	Manual	Using Magnetic Separator			
Cleaning of Sieves For Sorting	Done Every Time	Done Periodically			
Inspection of Sieves and Periodic Replacement	Inspected Periodically and Replaced	Breakdown Replacement			
Size of Sieves	Standard Size	Size deviates from standard			
Inspection Of Sieves For Corrosion, Bacteria Formation And Presence Of Foreign Materials	Inspected Regularly	Not stressed			
Inspection of Tea before Packaging for Presence of Harmful Residual Insecticides etc.	Inspected Every Time	Inspected Occasionally	Not Inspected At All		
Use of Standard Packaging Materials	TRA Standardized Packaging Material Used	Packaging Material not Standardized			
Inspection to Prevent Mixing of two Grades	Monitored Constantly	Occasionally Monitored			
Environment of the Packaging Room	Kept Dust Free Always	No/Least Effort for Protection from Dust			
Mode of Keeping the Unpackaged Tea	Kept Openly	Stored in Closed Container			
Cleanliness of Workers Engaged in Packaging	High Attention for Worker Cleanliness	No/Least Attention for Worker Cleanliness			
Level of Organized Effort put to Identify the "Points of Wastes" in Processing	High	Low	Very Low		
Capacity Utilization of Machines	High Utilization	Low Utilization			
Existence of Points of Congestion (Bottlenecks) in Processing	Flow of In-Process Tea is not Smooth, Point(s) of Congestion Exists	Smooth Flow of In-Process Tea			
Packaging Inspected For Air Tightness	Strict Inspection	Not/Least stressed			
Layout of the Factory	Good, Low Cost of Material Handling	Poor, High Cost of Material Handling			
Design of Factory Building and Roofing	Adequate Light Inside	Inadequate Light			
Rest Room in The Factory	Exists	No Such Separate Room			
Drinking Water, Lavatory Facility within the Factory	Satisfactory	Not Satisfactory			
Emergency Care Facility within the Factory	Satisfactory	Not Satisfactory			
Canteen Facility within the Factory	Exists	No such Facility			
Average Power Cut per Day in the Garden	> 8 Hours	4-8 Hours	2- 4 Hours	< 2 Hours	Captive Generation
Source of Primary Electrical Power	ASEB Power Supply	Captive Generation			
Source of Secondary (Stand-by) Power Supply	DG Set	Gas Turbine	No Source of Secondary Power		
Fuel for Dryer	TD Oil	Natural Gas	Coal		
Secondary Power Supply of the Garden Covers	Whole Garden	Factory only	Factory +Essential Infra-structures	No Source of Secondary Power	
Re-circulation of Exhaust Thermal Energy of Drying	Re-Circulated	Allowed to Escape to Atmosphere			

Stability of Voltage of Primary Power Supply	Very Stable (within 2%)	Stable (2-5%)	Unstable (> 5%)		
Ratio of Electrical Energy Consumption in Withering to Total Energy	20 - 25%	25 - 30%	> 30 %		
Ratio of Electrical Energy Consumption in Rolling/CTC to Total Energy	30-35%	35 - 40%	>40%		
Ratio of Electrical Energy Consumption in Fermentation to Total Energy	0 - 5 %	5 - 10%	>10%		
Ratio of Electrical Energy Consumption in Drying to Total Energy	20 - 25%	25 - 30%	> 30 %		
Ratio of Electrical Energy Consumption in Grading and Sorting to Total Energy	0 - 5%	5 - 10%	> 10%		
Ratio of Total Electrical to Thermal Energy in Processing	10 - 15%	15 - 20%	> 20%		
Total Electrical + Thermal Energy Consumption per Kg of Made Tea	3-4 KWH	4-5 KWH	> 5 KWH		
Average life of Electrical Equipment in the Factory	New	Old (>15 years)	Very Old (>25 years)		
Ratio of Ex-Factory (Under Estate Control)Electrical Energy Consumption to Total Energy	> 40%	30-40%	20-30%	10 - 20%	< 10 %
Capacity Utilization of the Machineries within the Factory	Operates at Highest Efficiency Most of the Time	Operates below Highest Efficiency Most of the Time			
Production Loss for Mal-Functioning of Electrical Equipment	Frequently	Rarely			
% of Unusable Electrical Equipment (Fans, Motors etc. in the Factory)	> 25 %	15- 25 %	< 15 %	0 %	
Status of Auxiliary (Supporting) Electrical Equipment in the Factory	Excellent	Good	Poor		
Mode of Storing Solid Fuels	Protected from Rain and Environmental Moisture	Kept Openly (No/Least Care Taken)			
Number of Electrical Equipment Consuming More than Rated	Many	A Few	None		
Electrical Power Theft from the Estate Cable Lay-out	A lot	A Few	None		
Calibration of Thermometers Used in Dryers	Calibrated Periodically	Not Calibrated Periodically			
Condition of House-Hold Cables and Inter-connections	Satisfactory	Not Satisfactory			
Number of Vehicles Under Estate Control	Redundant	Optimum	Deficient		
Record Sheet for Each Dryer to Ascertain Specific Fuel Consumption	Exists	No Record Keeping on this Aspect			
Energy Audit	Done Regularly	Not Done Regularly			
Competency of Garden Electrician	Skilled	Not skilled			
Equipment Modernization Programme of the Garden	Undertaken Frequently	Rarely Undertaken/ Not Undertaken			
Inspection for Malfunctioning of Electrical Equipment and Burner of Dryer	Frequent Inspection	Only in Overhauling Period			
Level of Management's Effort to Optimize Power Consumption	Encouraging	Discouraging			
Average Consciousness Level of Employees on Optimal Use of Energy	Very Conscious	Indifferent (Least Conscious)			

Size of Field Labour Force	Redundant	Optimum	Deficient
Average Experience of the Field Labour Force of the Garden	Highly Experienced (>10 years)	Experienced (5- 10 years)	Inexperienced (< 5 years)
Size of the Factory Labour Force	Redundant	Optimum	Deficient
Average Experience of the Factory Labour Force of the Garden	Very Much Experienced (> 15 years)	Experienced (7- 15 years)	Inexperienced (< 7 years)
Size of other Work-force of the Garden	Redundant	Deficient	Optimum
Size of Management	Redundant	Deficient	Optimum
Average Experience of Managerial Staff	Highly Experienced (> 15 years)	Experienced (5-15 years)	Inexperienced (< 5 years)
Average Experience of the Supervisory Staff	Highly Experienced (> 15 years)	Experienced (5- 10 years)	Inexperienced (< 5 years)
Regularity of Workers in their Job	Very Much Regular	Irregular	Very Irregular
Average Level of Communication Skill of the Workers	High	Poor	Very Poor
Management Perception on Motivating the Work-force	Very Difficult to Motivate	Very Simple to Motivate	Not Sure
Basis of Wage Payment	Volume of Work	Quality of Work	Both Volume and Quality
Average Level of Skill of the Work-force of the Garden	High	low	Very Low
General Level of Education of the Work-force of the Garden	Above Average	Average	Below Average
Job Knowledge of the Managerial Level Employees	Excellent, Very Much Confident	Good, Confident	Poor, Lacks Confidence
Average Idle-time of Garden Workers While on Duty	Above 30%	10-30%	Below 10%
Average Idle-time of Factory Workers While on Duty	Above 20%	10-20%	Below 10%
Transparency of Wage Payment System	Very Transparent, Workers Satisfied	Less Transparent, Doubt in Worker's Mind	Not Transparent At All
General Sense of Sanitation of the Work-force of the Garden	Satisfactory	Not Satisfactory	
Whether Child Labourers Involved in Any Garden Activity	Sometimes/Always	Never	
Learning Skill of the Employees of the Garden	Fast	Slow	Very Slow
General Urge of Employees for Improvement	High	Low	
Effective Proven Motivator for the Work-force	Money	Recognition	Promotion
Alcoholism Among the Workers	A Significant Problem	Not Significant	
Average Worker's Perception on Promotional Policy of the Garden	Quite Satisfactory	Dissatisfactory	Very much Dissatisfactory

Promotional Prospect for the Managerial Level Employees (as compared to other gardens)	Above average	Average	Below Average
Basis of Promotional policy of the Work Force	Time Bound	Performance Basis	Arbitrary
Basis of Promotional Policy for the Managerial Level Employees of the Garden	Time Bound	Performance Basis	Arbitrary
Employees are Proud for Being a Part of the Garden	Yes	Indifferent	
Type of Maintenance in the Factory	Routine and Annual Overhauling	Annual Overhauling	Only Breakdown Maintenance
Garden Has Factory Maintenance Schedule	Yes	No	
Status of "Safety" in the Garden	A Distinct Activity of the Garden	Not a Distinct Activity	
Separate Maintenance Schedule for All Machines	Exists	Does Not Exist	
Garden has a "Safety Slogan" and Followed	Yes	No	
Well Designed "Guidelines" for Operation of each of the Machines	Exists and Strictly Adhered To It	Exists, But Not Strictly Adhered	Does Not Exist
Number of Minor Accidents Took Place in the Garden in the Computing Period	Many	A Few	None
Major Accidents Took Place in the Garden in the Computing Period	Yes	No	
Condition Monitoring of the Machines in the Factory	Done Regularly	Done Occasionally	Not Done At All
Have Well Maintained Fire-Fighting System in the Factory	Yes	No	
Garden has Independent "Maintenance Crew"	Yes	No	
Type of Maintenance Carried Out for other Infra-Structural Facilities	Annual	Half Yearly	When Required
Protective Clothing During Application of Pests	Worn Every Time	Not Always	
Drains within the Factory	Kept Clean always	Not Attended Too Much	
Condition of the Hospital	Excellently Maintained	Well Maintained	Poorly Maintained
Condition of the Managerial Bunglows	Excellently Maintained	Well Maintained	Poorly Maintained
Condition of the Labour Quarters	Excellently Maintained	Well Maintained	Poorly Maintained
Condition of Garden Roads	Excellently Maintained	Well Maintained	Poorly Maintained
Condition of the Community Hall	Excellently Maintained	Well Maintained	Poorly Maintained
Condition of the Crèche	Excellently Maintained	Well Maintained	Poorly Maintained
Condition of Playgrounds	Excellently Maintained	Well Maintained	Poorly Maintained
Conditions of Vehicles Under Garden Control	Excellently Maintained	Well Maintained	Poorly Maintained
Guarding Moving Components within the Factory (Conveyors etc)	Guarded Properly	No Proper Guarding	

Overall Commitment of the Top Management for Maintenance Function	Very Much Committed	Least Committed			
Ex-Garden Welfare Rating of the Garden	Very High	High	Moderate	Poor	Very Poor
Level of Estate School for the Children of Employees of the Garden	Primary School	High School	No School		
Pattern of Funding the Estate School of the Garden	100% Estate Financed	Govt. Run, Infra-Structure Offered by Garden	No School		
Labour Welfare Officer in the Garden	Appointed	Not Appointed			
Activities of the Labour Welfare Officer	Garden Does Not Assign Plantation Activities to the Welfare Officer	Garden Assigns Plantation Activities to the Welfare Officer	Not Appointed		
Adherence to Norms for Supply of Protective Clothing for Pest Application	Full	Partial	Not Supplied At All		
Adherence to Norms for Supply of Concessional Cereal	As per Norms	Norms Deviated			
Crèche for Children of Working Women Labourers	Sufficient/ Good Operation	Insufficient /Poor Operation/No Crèche			
Condition of the Garden in terms of Health and Hygiene	Excellent	Good	Bad	Very Bad	
Emergency Health Care Facilities in the Garden	Satisfactory	Not Satisfactory			
Facility of General Treatment in the Hospital	Good	Moderate	Poor		
Size of Hospital Staff	Sufficient	Deficient			
Canteen Facility for the Garden Labourers	Well Maintained	Not Properly Maintained	No Canteen Facility		
Conformance of Labour Quarters as per Norms laid by Government	Full Conformance	Partial Conformance	Does Not Conform At All		
Health Consciousness Drive by the Garden	Undertaken Regularly	Undertaken Occasionally	Not undertaken at all		
Immunization Programme by the Garden	Undertaken Regularly	Undertaken Occasionally	Not undertaken at all		
Ambulance Service of the Garden	Satisfactory	Not Satisfactory			
Water Supply System of the Garden	Hygienically Maintained	Poorly Maintained			
First Aid Facility in the Garden and Factory	Present	Absent			
Periodicity of Drinking Water Testing	Regularly	Occasional	Never		
Provision of Paid Holidays	Exists	Does not exist			
Community Hall for Garden Labourers	Exists	Does not exist			
Playground for the Labourers	Exists	Does not exist			
Provision for Financial Assistance to Meritorious Students of the of Employees	Exists	Does not exist			
Policy for funding Welfare Activities Outside Garden	Exists and Strictly Adhered to it	Exists, Not Executed	Does not Exist		
Level of Commitment of the Top Management for the Development of the Garden	High	Low	Very Low		

"Quality Policy" of the Garden	Well Defined and Organized Effort for Attainment	Exists but Not Known to All	No Quality Policy	
Level of Participative Management in the Garden	High	Low	Poor	
Knowledge of Managerial Level People about the Factors Affecting Quality of Made Tea	High	Low	Poor	
Garden's Status as "Learning Organization"	High	Low	No 'Learning Concept' at all	
Rejection/ Low Price Realization of Lots of Garden Tea due to Poor Quality	Yes	No		
Level of Informal Interaction among the Managerial and Non- Managerial Staff	High	Low	Poor	
Use of Process Control Tools in Production	Used Extensively	Used in Certain Cases	Not Used at all	
Use of Organized Problem Solving Techniques in the Garden	Used Extensively	Used in Certain Cases	Not Used at all	
Management's Relation with the Trade Union	Harmonious	Conflicting		
Existence of Quality Circles, Problem Solving Groups where Non-Managerial People are also included	Exists and Functions Extensively	Exists But Poor Functioning	Does not Exist	
Garden Financed Research and Development Activities	Sizable Numbers	A Few	No Any	
Labour Strike in the Computing Period	Yes	No		
Lock-out of the Garden in the Computing Period	Yes	No		
Provision for Rewarding Employees for Good Work	A Common Practice	Sometimes	No Such Provision	
Mode of Rewarding Employees	Monetary	Promotion	Acknowledged Publicly	No Provision
General Morale of Employees of the Garden	Very High	Satisfactory	Low	
Training Programme for Managerial Level People	Conducted Regularly	Conducted Rarely	Not Conducted at all	
On Job Training Programme for Employees of the Garden	Conducted Regularly	Conducted Rarely	Not Conducted at all	
Record Keeping in all aspects of the Garden	Systematic	Haphazard	No Record Keeping	
Theft of Tea Leaves of the Garden	A Serious Problem for the Garden	Not A Serious Problem For the Garden		
Theft of Made Tea of the Garden	A Serious Problem for the Garden	Not A Serious Problem For the Garden		
Use of Computers in the Garden Activities	Extensive	In some Aspects only	Not used at all	
Fixation of Span of Control of Asstt. Managers, Sirders, Supervisors	Based on Experience	Traditional		
Leadership Capability of the Managerial Staff	Very High	Satisfactory	Low	
Worker's Knowledge about Plantation and Processing Aspects Contributing to Quality of Tea	High	Low		

Employees Follow Instructions of Managers/Sirdars of the Garden	As they Love to Work	As, they fear of Punishment		
Conflict between Employees and Managers	Never	A Regular Affair		
Employees Are Proud of Being a Pert of the Garden	Yes	No	Indifferent	
Rate of Bonus Paid in the Computing Period	8.33%	> 8.33 but < 15%	> 15%	No Bonus Paid at all
Mode of Bonus Payment in the Computing Period	Single Installment	>1 Installment	Not Paid at all	
Decision on 'Rate of Bonus Payment'	Decided after Consultation with the Trade Union	Decided Unilaterally		
Period of Bonus Payment	Before Festivals	After Festivals	Not paid at all	
Management's Readiness for Initiation of Cultural Change	Ever-Ready Set of Managerial Staff	Probable Resistance may result		
Employee's Readiness for Cultural Change	Ever- Ready; Tuned Set of Employees	Probable Obstacle for Change		

Excellently Maintained : High Conscious Effort, Delighted Users
Well Maintained : Routine Effort, Satisfied User
Poorly Maintained : Little or No Effort, Dissatisfied User

Thank you for your cooperation

Appendix- II

Appendix- II A: Specification of Machineries and Equipments in the Garden Selected for Study of Maintenance Activities

1. Withering System:

Parts	Specification
Withering Trough	Bottom Length : 15-40 m (150'-120') Width : 1.8-3.6 m (6'-12') Height : 1.2-1.5m(3.9'-4.9')
Blower Fan	Fan diameter : 40"-54" R.P.M. : 720-960
Motor	H.P. : 3-10 R.P.M. : 720-960
4-A Burner	Diameter : 5.9'
Dry and Wet Bulb Thermometer	----------------

2. CTC System:

Parts	Specifications
CTC Machine	24",30",36",48"
Forged CTC Stainless Steel Segments	Diameter : 8.5"
CTC Roller High speed- Slow speed-	Diameter : 8.5" T.P.I. : 8-10 R.P.M. : 1400-1440 : 700-720
Hygienic conveyer Belts	Width : 36"
Magnetic Bars	Width :36"
Stainless Steel Rotor vane and spares	15"& 8"
Sprocket	Teeth : 35 &45
Scraper	Width : 36"
Motors	H.P. : 30,25, & 25
Worm	8" & 6"

3. Fermentation System:

Fermentation Room

Parts	Specification
Fermenting Floor Tiles	Not Fixed
Axial Flow Fan	Speed :720-920

4. Humidification Chamber:

Parts	Specification
Axial Flow Fan	Speed : 2860 H.P. : .75 Fan Diameter : 40"-54"
Centrifugal Fan	Speed : 625-1760 H.P : 3-10 Impeller Diameter : 18"- 40"

5. Drying System:

5 A. Air Heater:

Overall Weight : 15.5 -22 tones

Parts	Specification
Heating Chamber	Hot air Capacity at 210 °F 16000-40000 CFM
Tube Banks	No of tubes : 16, 20, 32, 40 Length : 6'2"
Fire Bricks	Length : 9" Breadth : 4.8" Height : 1.8"

5 B. Drier:

Parts	Specification
Gear Boxes	———
Bearings	———
Main Drives Chains	———
Trays	———
Grid Plates	———
Discharge Valve	———
Centrifugal Fans	Impeller Diameter : 18"-40"

6. Sorting System:

<table>
<tr><th>Parts</th><th>Specifications</th></tr>
<tr><td>Fiber Rollers</td><td>Length : 36"
Diameter : 8.5"</td></tr>
<tr><td>Dimple Tray</td><td>Not Fixed</td></tr>
<tr><td>Electric bulb</td><td>60 Watts</td></tr>
<tr><td>Vibrating sieve</td><td>Holes per inch :
<table>
<tr><td>Grade</td><td>Over</td><td>Through</td></tr>
<tr><td>B.P.(S)</td><td>10</td><td>-</td></tr>
<tr><td>B.O.P.</td><td>12</td><td>10</td></tr>
<tr><td>B.P.</td><td>18</td><td>14</td></tr>
<tr><td>P.F.</td><td>24</td><td>18</td></tr>
<tr><td>P.D.</td><td>30</td><td>24</td></tr>
<tr><td>D.</td><td>40</td><td>30</td></tr>
<tr><td>C.D.</td><td>50</td><td>40</td></tr>
</table></td></tr>
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Appendix- II B: The Proposed Maintenance Schedule

SYSTEMS	COMPONENTS	PARTS		MAINTENANCE			MAINTENANCE ACTIVITY
		MOVING	STATIONARY	FREQUENTLY	DAILY	ANNUAL	
ROLLING	CTC ROLLER	ROLLER (HIGH SPEED; SLOW SPEED)		✓			Sharpening teeth, Reduce overloading & pressure
		HYGIENIC CONVEYER BELT				✓	Replacement
		STAINLESS STEEL ROTORVANE			✓	✓	Overhauling & cleaning
		SPROCKETS			✓	✓	Lubrication and inspection
		SCRAPER			✓		Cleaning
		MOTORS			✓		Inspection
		WORMS			✓		Cleaning
		V-BELTS				✓	Replacement
		SIEVE			✓	✓	Cleaning & Replacement
			CTC MANDREL, HOUSING BLOCKS			✓	Lubrication
			FLAT MAGNETIC BAR	✓			Cleaning

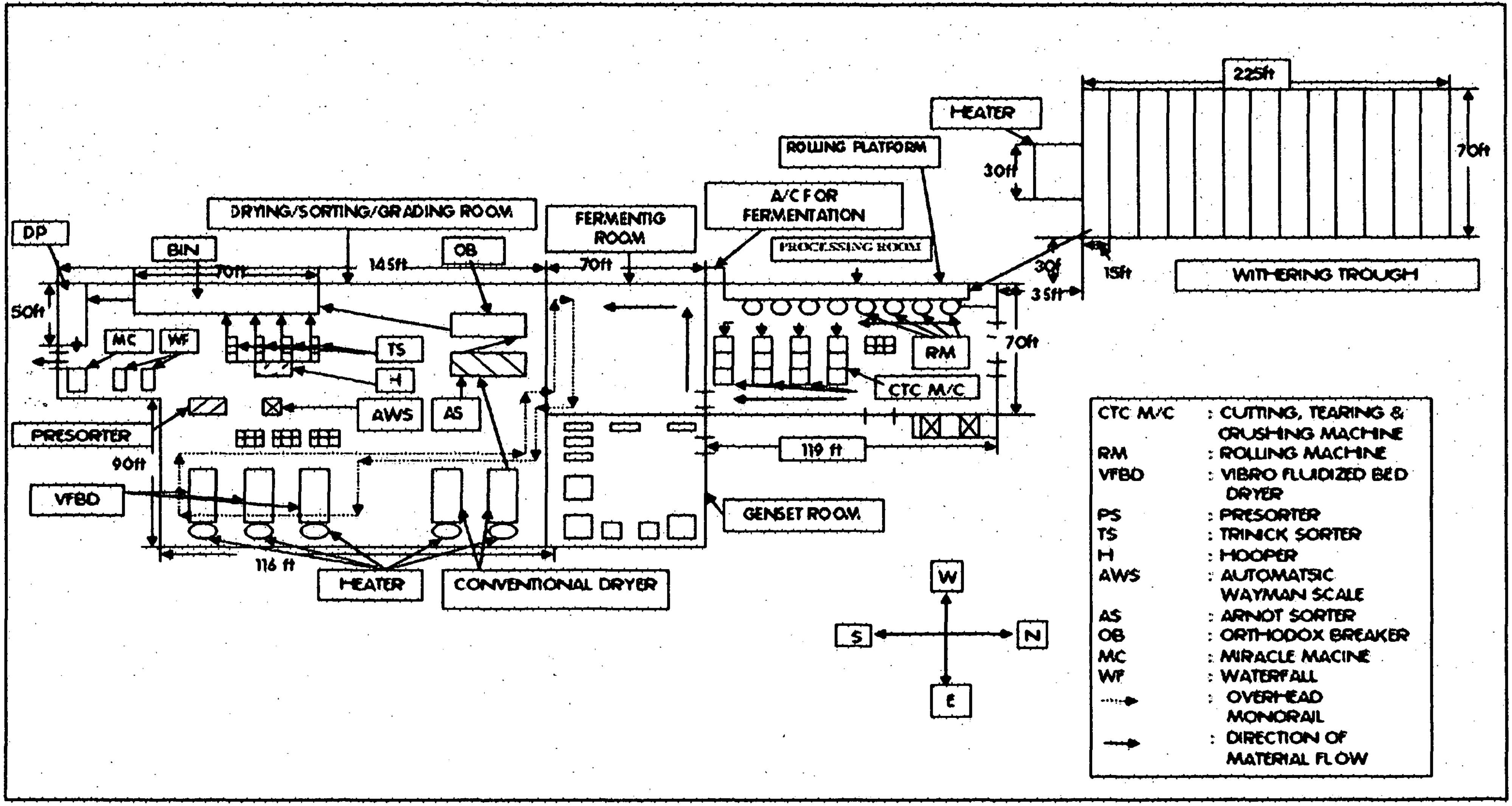
SYSTEMS	COMPONENTS	PARTS		MAINTENANCE			MAINTENANCE ACTIVITY
		MOVING	STATIONARY	FREQUENTLY	DAILY	ANNUAL	
FERMENTATION	FLOOR		TILES		✓		Cleaning
			THERMOMETER	✓			Inspection
	HUMIDIFICATION CHAMBER	AXIAL FLOW FAN				✓	Annual overhauling
		CENTRIFUGAL FAN		✓		✓	Cleaning and regular inspection
			WATER SPRAYER NOZZLE		✓		Cleaning

SYSTEMS	COMPONENTS	PARTS		MAINTENANCE			MAINTENANCE ACTIVITY
		STATIONARY	FIXED	FREQUENTLY	DAILY	ANNUAL	
DRYING	FURNACE	CHAIN GATE STOKER				✓	Annual overhaul
		CENTRIFUGAL FAN		✓		✓	Noise & vibration inspection Lubrication of fan bearing with the heat resistant grease
			STOVE TUBES		✓		Cleaning
			TUBE BANKS		✓		Cleaning

			FURNACE BACK PLATE		✓		Cleaning
			FIRE BRICK LINING			✓	Replacement
			ECONOMISER TUBE		✓		Cleaning
	DRIER	BEARING		✓			Lubrication once in a week
		MAIN DRIVE CHAIN				✓	*Check the pins* and condition of the chain after 400 running hours
		GRID PLATES			✓		Check the slots whether it is choked, clean with a steel Wire brush
		TRAYS			✓		Check if any trays are jammed and clean the chain pin and cast iron tray bush, with a emery cloth
		Discharge Valve		✓			Clean the fluff from the grooves of the gear and the pinion. Lubricate all the idler sprockets and jockey sprockets once a week. Lubricate the chain once in three months (except the tray carrying chains)
			GEAR BOXES			✓	Oil replacement after 500 hours of operation. Next oil change after 3000 hours (SAE 60)
			PRESSURE GAUGE	✓			Inspection
			THERMO METER	✓			Inspection

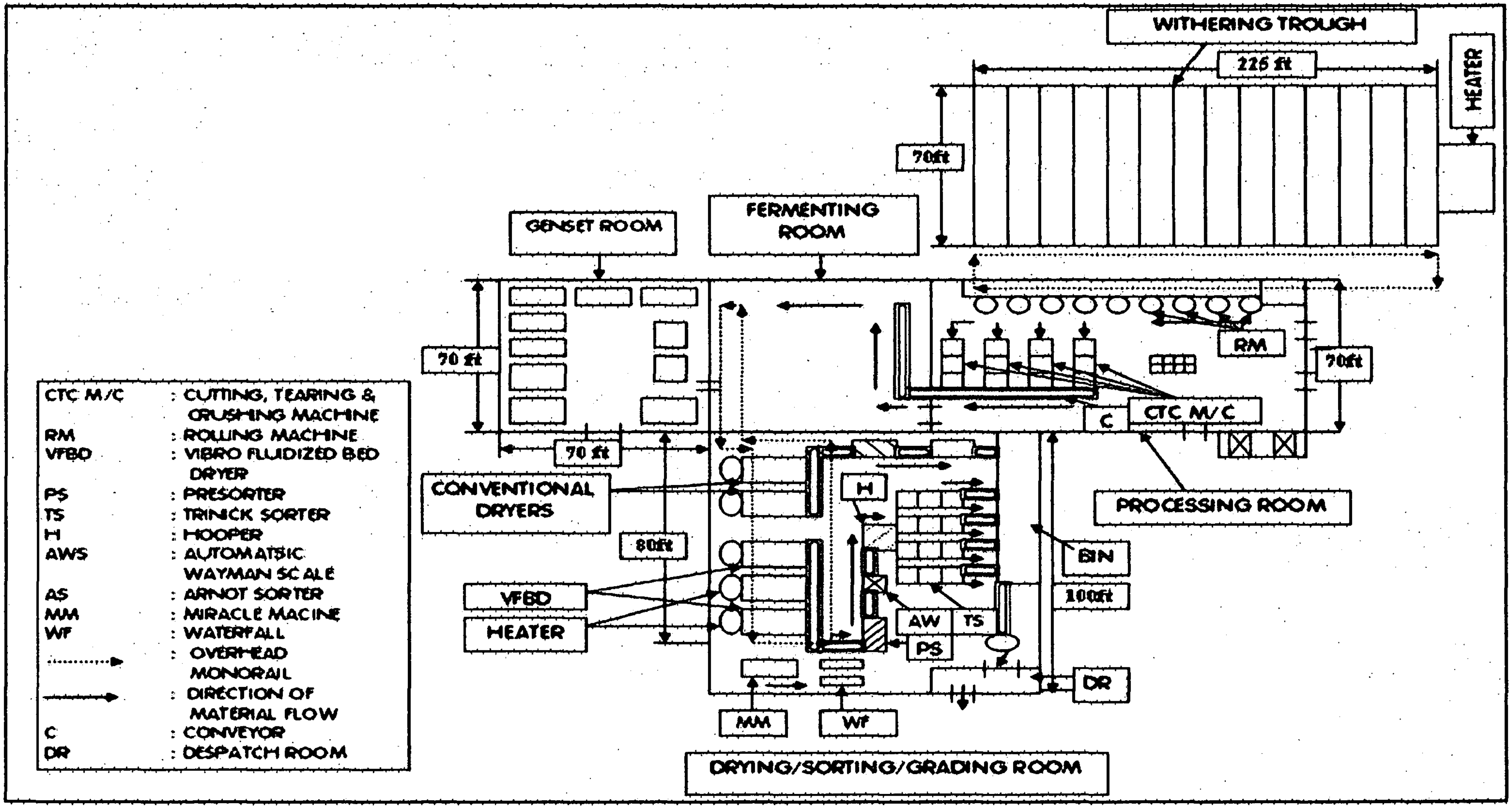
Appendix- II C

The Existing Layout of the Factory of the Garden Selected for Study



Appendix- II D

The Proposed Modifications in the Layout of the Factory



Appendix- III

The Utility Concept

A customer evaluates a product on a number of diverse quality characteristics. To be able to make a rational choice, these evaluations on different characteristics should be combined to give a composite index. Such a composite index represents the utility of a product. The overall utility of a product measures the usefulness of that product in the eye of an evaluator. However, the utility of a product on particular characteristics measures the usefulness of that particular characteristic only. Overall utility of a product is the sum of utilities of each of the quality characteristics.

Thus if X_i is the measure of effectiveness of an attribute (characteristic) i and there are n attributes evaluating the outcome space, then the joint function can be expressed as

$$U(X_1, X_2, X_3, \ldots\ldots X_n) = f(U_1(X_1), U_2(X_2), U_3(X_3), \ldots\ldots\ldots\ldots U_n(X_n))$$

where $U_i(X_i)$ is the utility of the i^{th} attribute.

Assuming that the attributes (characteristics) are independent and have no interactions between themselves, and the overall utility function is a linear sum of utilities, the overall utility function becomes

$$U(X_1, X_2, X_3, \ldots\ldots X_n) = \sum_{i=1}^{n} U_i(X_i)$$

Depending upon the customer's requirements, the attributes may be given priorities. The priorities can be adjusted by providing a weight to the individual utility index. The overall utility function by assigning weights to attributes can be written as

$$U(X_1, X_2, X_3, \ldots\ldots X_n) = \sum_{i=1}^{n} W_i U_i(X_i)$$

Where W_i is the weight assigned to the attribute i and the sum of the weights for all attributes is equal to 1. The utility function is of 'higher the better type'. If the composite measure (the overall utility) is maximized, the quality characteristics considered for the evaluation of utility will automatically be optimized (maximized or minimized whichever case may be).

To determine the utility value for a number of quality characteristics, a preference scale for each quality characteristics is constructed. Later these scales are weighted to obtain a composite number (Overall Utility). The weighing is done to satisfy the test of indifference on the various quality characteristics. The preference scale may be, for example, linear, exponential or logarithmic. The minimum acceptable quality level for each quality charcerisitics is set at a preference number of 0 and the best quality characterisitics is assigned a preference number of 9 (the preference numbers for minimum or best value of quality charcterisitcs is optimal). If a log scale is chosen, the preference number (P_i) is given as

$$P_i = A \log (X_i / X_i')$$

Where X_i is the value of quality characteristic or attribute i, X_i' is the minimum acceptable value of the quality characteristic or attribute i and A is a constant.

Arbitrarily, we may choose A such that Pi = 9 and Xi= X^*, where X^* is the optimal value of assuming such a number exists.

The next step is to assign weights or relative importance to the quality characteristics. The weights should be assigned such that the following condition holds:

$$\sum_{i=1}^{n} W_i = 1$$

The Overall utility can be calculated as:

$$U = \sum_{i=1}^{n} W_i P_i$$

References:
Kumar Pradeep, Barua PB., Gaindhar GL.; 2000, "Quality Optimization (Multi-Characteristics) Through Taguchi's Technique and Utility Concept", Quality & Reliability Engineering International, Vol:16, pp 475- 485

Darek WB; 1982, "Analysis of Optimal Decisions", John Wiley & Sons, New York

Appendix IV-A

Grades of Tea Workers in Tea Estates

(Source: ATPA Circular No G-8/45 dated 25.06.1996)

For each category of employees in the Tea Plantation the Wage Board introduced three Grades under:

- Daily Rated Workers : Man, Woman, Children
- Sub-staff and other monthly rated workers : Grade I, Grade II, Grade III
- Clerical Staff : Grade I, Grade II, Grade III
- Medical Staff : Grade I, Grade II, Grade III
- Technicians and Artisans : Grade A, Grade B, Grade C

There are certain uncommon categories like Superintendent Office Staff, Group Engineers, Group Hospital Clerks, Foreman, Factory Supervisors etc.

Daily Rated Workers:

(i) Man: All male workers working in the field, factory and offices who have completed their 18 years of age

(ii) Woman: All female workers working in the field, factory and offices who have completed their 18 years of age

(iii) Children: All persons male or female who have not completed their 18 years of age.

These three categories of daily rated Plantation Workers are brought into two categories from 1.11.89 as under:

a) Adult Workers (both Male and Female)

b) Non- Adult Workers (both Male and Female)

Sub-staff and other monthly rated workers:

Grade I : Categories of employees like Overseers (head mistries), head foreman. None of the Sub-staff employed in the Tea Estates of Assam were allowed this Grade I under Central Wage Board's Recommendations.

Grade II : Sirdars, Hazira Mohorers, Kamjari Babu, Nurses without Nursing Certificates and Mid-wives without certificate but trained locally are included., Grade III: Line and Factory Chowkidars, Gate Chowkidars on permanent posts, Chowkidars already monthly rated, Dak-wallahs, Jugali Sirdars, Nursing Attendants, Dressers, untrained Mid-wives.

Clerical Staff

Grade I : Head Clerks, Senior and Head Factory Clerk,

Grade II: Senior Garden Mohorers/clerks, 2nd Clerks in Office, 2nd Factory Clerks/Mohorers, Senior Stores Clerk

Grade III: Typists, Senior Garden Office and Factory Clerks, Asstt. Stores Clerks, School Teachers (Company Employed)

Medical Staff:

Grade I: Asstt. Medical Officers, all Doctors and other Medical Employees of similar status

Grade II: Laboratory Technicians (Medical), Radiographers, Theatre Sisters, Staff Nurses

Grade III: Pharmacists, Meteorologists, Trained Nurses

Artisans and Technicians

Grade A: Assam Grade I Artisans

Grade B: Head Electricians, Boiler Attendants

Grade C: Grade III Artisans of Assam

Appendix IV- B

Prohibition of Child Labour in Tea Industry

The Government of India has decided upon a programme to eliminate child labour from the hazardous occupation by 2000. By the Child Labour (Prohibition and Regulation) Act 1986, it has banned the employment of children below 14 years in Factories, Mines and hazardous employment.

The Plantation Labour Act 1951 defines the "Child" as a person who has not completed his fifteenth year. The Industrial Committee on Plantations in its meeting held on 20th October 1995 in New Delhi has recommended: - "No child below the age of 14 years shall be required or allowed to work in any plantation".

Appendix IV- C

Mandatory Welfare Activities As Prescribed By Law for Garden

(Source: ATPA Circular No G-8/45 dated 25.06.1996)

Fringe Benefits:

- Statutory Fringe benefit: PF Benefit, Annual Leave with wage, Sick Leave, Payment of Bonus, Payment of Gratuity, Maternity benefit, protective clothing, other benefits
- Non- Statutory Benefit: Sick Leave to temporary workers, Casual Leave to Sub-Staff
- Paid Holidays
- Sick Leave with wages in cases of serious, prolonged or terminal illness
- Supply of concessional food grains to the workers and staff
- Supply of fire wood to labourers
- Supply of concessional electricity
- Free accommodation
- Leave Travel Allowance
- Water Supply
- Free LPG to Staff
- Free scheduled drugs

Payment of Bonus:

Under the Payment of Bonus Act, 1965 as amended up to date, it is obligatory on the part of the employer to pay a minimum bonus @8.33% of annual earnings or Rs. 100.00 whichever is more, whether there is allocable surplus or not to all employees working for 30 days or more an an accounting year and drawing a wage or salary not exceeding Rs 3500.00 per month, subject to a maximum of 20%.

It is provided in the Act that while computing the allocable surplus, the amount set-on or set-off for the previous three years, shall be taken into consideration and for the employees drawing a salary or wage not exceeding Rs. 3500.00 per month, the annual earnings are to be calculated as if those employees were receiving salary or wages at Rs 2500.00 per month.

Protective Coatings:

Under Rule 71 of the Assam Plantation Labour Rules, every employer is required to supply to every worker free of cost:-

a) one umbrella for every two years (best quality with thickly woven canopy which can withstand at least two Assam rainy season)
b) one blanket or Jersy for every two years (100% Woolen weighing not less than 1200 grams, length 1.98m and breadth 1.21 m)
c) one pair of chappal for every year (good quality marketed by BATA shoe Company or Calcutta Shoe Company
d) one rain coat for every two years (silicon treated or rubber impregnated up to ankle length for woman, knee length for men)

Other Statutory Fringe benefit:

- Supply of wholesome drinking water
- Medical facilities for workers and their families up to the standard available in the Group Hospital
- Crèches in every plantation where number of workers is 50 or more, for use of children with paly-things under a woman crèche-in-charge
- Canteens in plantation having 150 workers or more with food staff at subsidized rate
- Schools are to be provided and maintained in those plantation where the number of children between the ages of 6 to 12 exceeds 25, if there is no primary school under direct management of the state government
- Free housing accommodation (with at least three living rooms) of approved standard and specification by the State government to the workers and families residing in the plantation.

Chart for Concessional Cereal Ration Entitlement under Minimum Wage Notification (GLR/29/55/40 dated 31.4.55 revised 6.2.91)

Number of days worked in a week	Concessional Cereal Ration Entitlement per week (Kg)		
	Adult Worker	Adult Dependent	Minor Dependent
5 or 6 day's work	3.26	2.44	1.22
4 day's work	2.33	1.74	0.87
3 day's work	1.40	1.05	0.53
2 day's work	0.46	0.35	0.18
1 day's work	NIL	NIL	NIL

Appendix IV- D

Pest Control Calendar

MONTH	INSPECT	FOR	ACTION
January onwards	1-2 year old pruned wood mature leaves of young tea	Borer Red spider	Prune out affected stems Spray
January/ February September/October March	 Pruned tea Whole Garden, Shade, Mature tea and nurseries	 Termites Mites Looper Cricket	 Soil and frame treatment Spray Spray Treat burrows
Throughout tipping period	Whole Garden	Mites, borers Fl ush worm Red Rust Discolored leaf	Spray Pluck-off and Spray Spray Diagnose & treat
April- May	Maintenance Leaf Treatment	Black Rot	Spray
May-June	Young Tea	Cockchafer Grub	Soil Treatment
July- August	Maintenance Leaf	Black Rot	Spray
November–December	Maintenance Leaf and Stem Pruned Tea Young Tea	Black Rot Nectria & Poria Mites	Spray Prune Out Spray
Throughout Year	Whole Garden	Dead bushes	Uproot and diagnose

[Source: The Planters' Handbook: TRA, Tocklai Experimental Station]

Appendix IV- E

TRA Certified Garden Clones for Plains

Assam : South Bank (49 clones)		Assam : North Bank (29 clones)
TRA/ Amluckie 84 *	TRA/Halwating12*	TRA/Baghmari 10*
TRA/ Amluckie 10J *	TRA/Haluwating 15*	TRA/Baghmari 20***
TRA/ Borahi 21*	TRA/Kaliapani 1*	TRA/Baghmari 35**
TRA/Borahi 33**	TRA/Kaliapani 20*	TRA/Bormajan 2**
TRA/Borahi 38 **	TRA/Kaliapani 37*	TRA/Bormajan 5*
TRA/Borsillah24*	TRA/Kaliapani 25 ***	TRA/Bormajan 19*
TRA/Borsillah3A*	TRA/Khomsong 23*	TRA/Choibari27*
TRA/Bukhial 21*	TRA/Khomsong 29**	TRA/Choibari 38*
TRA/Bukhial 46	TRA/Teloijan22*	TRA/Choibari43*
TRA/Cherideo Purbat 23*	TRA/Sangsua 28*	TRA/Dhul 41*
TRA/Dahingeapar 24/18*	TRA/Sangsua 40A**	TRA/Dhulapadang10*
TRA/Digulturrung2/14*	TRA/Sangsua 42*	TRA/Dhulapadang36*
TRA/Dilli 11*	TRA/Sangsua 6*	TRA/Gohpur33**
TRA/Dilli 36*	TRA/Thowra 2/11*	TRA/Kacharigaon5*
TRA/Dilli 62*	TRA/Tingalibam 3/38*	TRA/Kolony 26*
TRA/Dilli72*	TRA/Manohari 4/16*	TRA/Mazbat107*
TRA/Dinjoy16*	TRA/Manohari 6/5*	TRA/Mazbat110
TRA/Dooria4*	TRA/Mokrung 76*	TRA/Mornoi30*
TRA/Dooria15*	TRA/Numbernadi 42*	TRA/Mornoi33*
TRA/Gabroo Parbat19*	TRA/Numbernadi 10*	TRA/Nagrijuli5/70*
TRA/Gootonga 20*		TRA/Nagrijuli6/24***
TRA/Gootonga 30*		TRA/Nagrijuli7/38*
TRA/Gopal Krishna 18*		TRA/Nagrijuli14/75*
TRA/Gopal Krishna 31*		TRA/Seajuli8***
TRA/Heeleakah 22/14*		TRA/Seajuli16***
TRA/Heeleakah 23/14*		TRA/Seajuli19***
TRA/Heeleakah 23/15*		TRA/Seajuli25*
TRA/Heeleakah 23/19*		TRA/Tarajuli 34*
TRA/Heeleakah 23/36*		TRA/Tarajuli 37*

* Standard Clones : With above average yield and quality

** Quality Clones: With very high quality but average yield

*** Yield Clone: With very high yield but average quality

[Source: The Planters' Handbook: TRA, Tocklai Experimental Station]

Appendix IV- F

Check list for Poor Results in Nursery Activities

Effects	Causes
High mortality of plants	Brown wood – too dry, insufficient shade Soft bark- too wet
Cutting alive but does not root	Weak cutting, damaged stem, over shaded, waterlogged, sub-acid soil
Excessive callus and feeble roots	Soil too rich in organic matter, water logged, sub-acid soil
Poor Growth	Leaves yellow and limp – eelworm Leaves pale- water logging or nutrient deficiency Leaves hard- too dry
nternodes and leaves pale	Over shading
Rosetting, leaves turning white, sickle leaves	Micro-nutrient deficiency, Zinc deficiency
Causes of water logging	Sleeve soil not permeable and free draining, mud scald between sleeve and bed, excessive rain/irrigation, poor drainage system

Appendix IV- G

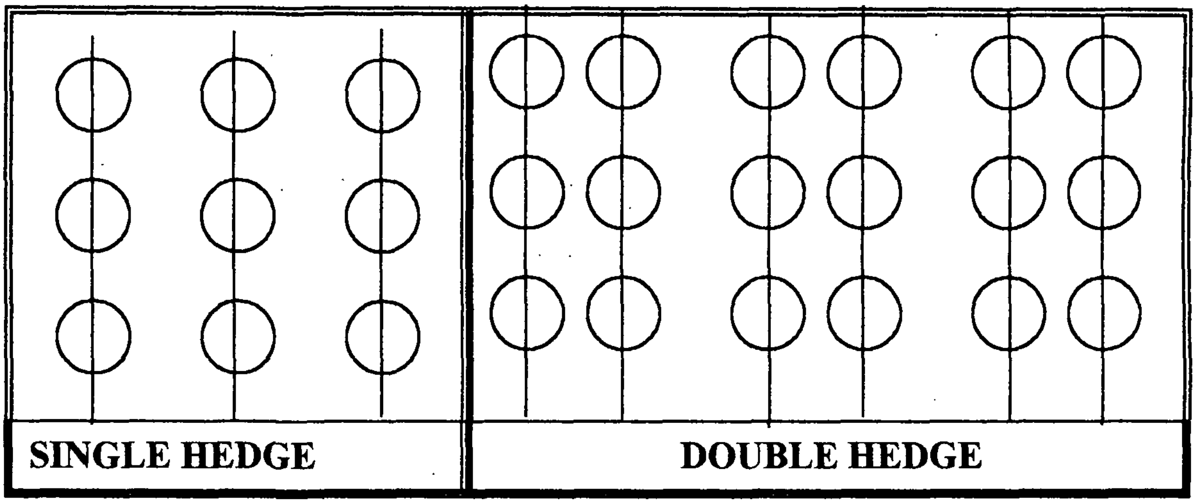
Recommended Shade Trees [TRA, India] for Assam

Shade Trees of Tea Gardens

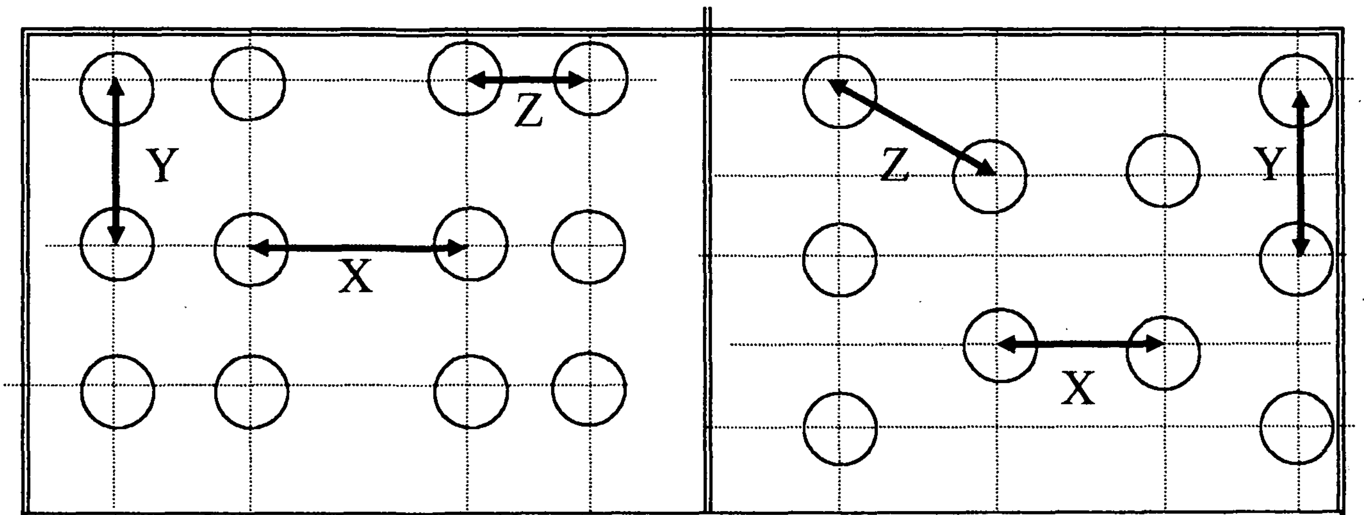
Type	Spacing/Number	Species
Temporary	4 x 4 m 625/ha	Indigofera teysmanii, Sesbania aegyptiaca, Leucaene leucocephala, Melia azedarach, Gliricidia maculeata
Semi-permanent	6 x 6 m 275/ha	Albizzia Chinensis
Permanent	12 x 12 m 68/ha	Albizzia odoratissima, Albizzia lebbek, Albizzia procera, Derris robusta, Acacia lenticularis, Dalbergia sericea, Adenanthra pavonina

Appendix IV- H

Mode of Plantation



Spacing Between Plants (Double Spacing)



Y= distance between bushes in a tea line
X = distance between hedges
Z= distance between tea lines (regular double hedge)
= distance between bush in one line and nearest bush in adjoining line (staggered double hedge)

Specification for Single Hedged Plantation : X and Y
Specification for Double Hedged Plantation : X, Y and Z

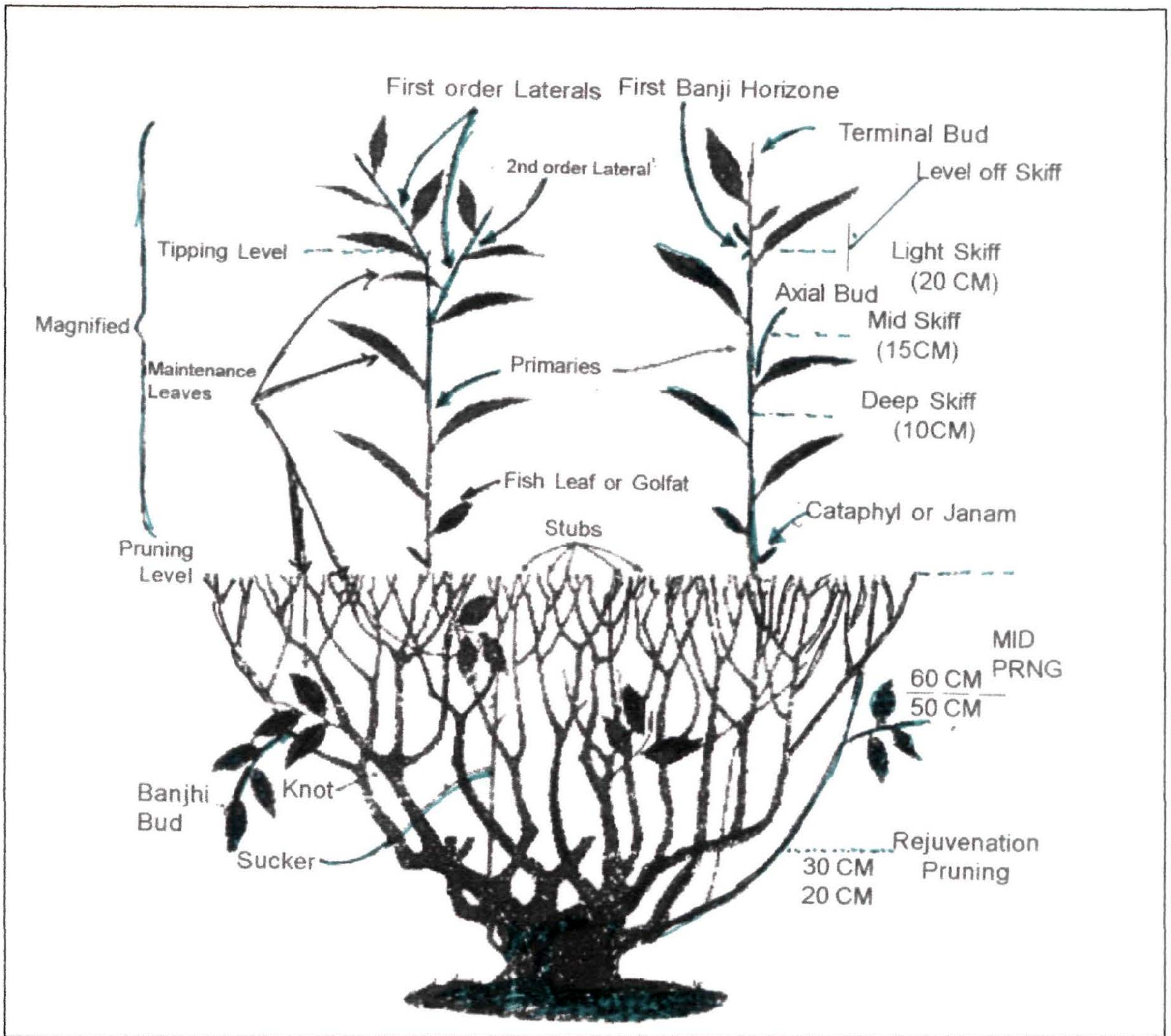
Appendix IV- I

Some Spacing with Calculated Populations

Spacing	Calculated Plant population per hectare
105 cm x 70 cm x 75 cm (double hedge)	17316
110 cm x 70 cm x 70 cm (double hedge)	15873
110 cm x 75 cm x 75 cm (double hedge)	14414
110 cm x 75 cm x 70 cm (double hedge)	14815
110 cm x 70 cm x 65 cm (double hedge)	16326
110 cm x 70 cm x 60 cm (double hedge)	16806
90 cm x 60 cm (Single Hedge)	18518
100 cm x 60 cm (Single Hedge)	16666
105 cm x 60 cm (Single Hedge)	15873
105 cm x 65 cm (Single Hedge)	14652
105 cm x 70 cm (Single Hedge)	13605
105 cm x 75 cm (Single Hedge)	12698

Appendix IV- J

Pruning Standards



The Tea Plant

Prune Designation	Type of Prune	Details
CP	Collar Prune	All above ground portion is cut leaving only up to a maximum of 10 cm when bush frame becomes unproductive and root system is still healthy
RP	Heavy/Rejuvenation Prune	40-45 cm above ground for renewal of frame
MP	Medium Prune	50-65 cm above ground for top frame renewal and height reduction
HRP	Height Reduaction Prune	70-75 cm above groud for height reduction
LP	Light Prune	4-5 cm above last prune to renew the wood for growth of new branches and clean out the bush
DS	Deep Skiff	1. At 10 cm measure above the light prune mark where 20 cm tipping measure is followed in the LP year in a LP-DS sequence 2. At 12-13 cm measure above the light prune mark where 23-26 cm tipping measure is followed in the LP

		year irrespective of sequence of pruning/skiffing 3. At 12-13 cm measure above the light prune mark irrespective of tipping measure the LP year in a LP-UP/LOS-DS sequence
LOS	Leve-off Skiff	5 cm above current year's tipping level used to cut off the highest plucking point and level up
MS	Medium Skiff	Just below majority of crow's feet to remove congestion
LS	Light Skiff	At current year's tipping level to re-establish a level
UP	Unpruned	Untouched/levelled by hand
CA	Cut Across Prune	Removal of one or more year's old wood leaving only 3-5 cm with a slashing knife of 20-25 cm length
CL	Clean out prune	Small snags and knots and unproductive shoots are cut following CA CA + CL = LP
DSN	Desnag Prune	Snags, knots and dead wood are cut out following MP etc. and the cuts are smoothened
	Decentre Prune	Cut-off main stem at 15-22.5 cm retaining 2/3 or more healthy laterals below in a young plant
	Lung Prune	A partial cut for decenter, leaving connection between bottom and top shoot
	Finger Prune	Like lung pruning, done by partial breaking of the stem

3-4 year cycle : LP-UP-UP, LP-DS-UP, LP-UP-DS. LP-MS-DS, LP-UP-DS-UP

Tipping Height		
LP	**:**	**20-26 cm (Average height of 5 leaves)DS**
	:	**7 – 10 (Avarage height of 2 leaves)**
MS	**:**	**4-5 cm (Avarage height of 1 leaf)**
LS	**:**	**at skiffing level of janam**
LOS	**:**	**at skiffing level to janam**
UP	**:**	**at last level of plucking**
CP	**:**	**70-75 cm**
RP	**:**	**25- 35 cm**
MP/HRP	**:**	**25 – 30 cm**

Appendix IV- K

Rejuvenation Calendar

Year	Time	Action
-2	Spring	All the vacant spaces should be planned with Guatemala for rehabilitation Establish shade nurseries @ 200% of calculated requirements
-1	Spring	Plant shade, both temporary and permanent; keep infilled, build up soil potash status
	Autumn	Establish tea nurseries Leave sections unprunned, ring overaged shade
0	Spring	Apply normal dose of N and P2O5; additiona k2O need to be applied based on K status
	September	Rest, remove dead shade, fill saucers
	November	Infill if soil is moist and mulch, defer to spring if dry
	December	Cut back the poria and termite infested or dead branches to the healthy part; uproot the bushes infected by primary root diseases
+1	January	Survey, repair or realign drains
	Spring onwards	Revise infilling, mulch and shade, apply NPK (2:1:3) : N (90 – 130 Kg/ha) Tip at 80 -90 cm from ground irrespective of height of prune, 100% pest and weed control
	December	C/A and desnag (LOS if weak), infill the vacancy created by dead infills and also bushes which failed to recover
+2	Spring	Head back and remove strong center and cross branches of infills at 40 cm. Pluck at same height with other bushes. Now,follow all other field practices at highest standard
	December	LP and revise desnag. Infills cut across at 45-50 cm and tip at same height as in old bushes

Appendix IV- L

TRA Disease Control Measures

Disease	Symptoms	Control
Black rot	Infected tea leaves in Spring	Prune, clean out, caustic wash Prophylactic spraying If persists treat with copper oxychloride Two monthly rounds of 'Carboxin/COC' at 1: 400 dilution during November – December
Blister Blight	Tender young leaves and stems are infected, builds up rapidly in over-shaded regions	Time pruning operations to reduce regrowth In autumn- prune or skip-off Pluck hard and black till the disease disappears
Primary root disease	Part of a mature bush (or all of it) dies suddenly, dead leaves remain attached	Good land clearing followed by 2 years rehabilitation Affected bushes and the ring of adjoining bushes have to be uprooted, removed and burnt
Secondary Root disease	Affected roots violet/black, unpleasant smell: Violet root rot Root bark normal but wood inside with faint black lining, only on debilated bushes: Diplodia	Rectify drainage, shade and soil aeration. In case of death, only the dead bush has to be uprooted
Branch Canker Branch Dieback Thorny Stem Blight	Spread throughout the frame Kills the bush	Pruning cuts or mechanical wounds are to be painted with bitumen paint Knife cleaning of diseased branch before painting Apply 5 – 10% spore suspensions of Trichoderma bioformulation immeadiately after pruning If bushes die, only diseased bush has to be uprooted
Red rust	Discoloured leaves (more often young tea) and die back lateral; Orange/red patches on stem: April/June Purple black patches: August- March	Bushes suffering from bad drainage, insufficient or unbalanced fertilizer, adverse soil pH, poor shade
Brown Blight Grey Blight	Old, weak, diseased or damaged leaves	Control causes, not by sraying
Sun Scorch	Leaves: Burnt by heat after rain Braches: Bark burnt in patches if pruned before November	Retip Raise shade in advance, white-wash, keep pruning litters on top of frame for reducing direct sunlight
	Herbicide damage	Control application

Appendix V- A

Scores Used in the TQMI Model (Scale: 0 – 10)

Garden Sector							
G_1X_1	10	$G_{14}X_2$	2	$G_{29}X_3$	9	$G_{45}X_1$	10
G_1X_2	8	$G_{15}X_1$	10	$G_{29}X_4$	6	$G_{45}X_2$	7
G_1X_3	4	$G_{15}X_2$	3	$G_{30}X_1$	3	$G_{45}X_3$	2
G_2X_1	9	$G_{16}X_1$	10	$G_{30}X_2$	6	$G_{46}X_1$	6
G_2X_2	7	$G_{16}X_2$	9	$G_{30}X_3$	8	$G_{46}X_2$	8
G_2X_3	4	$G_{16}X_3$	7	$G_{30}X_4$	7	$G_{46}X_3$	3
G_3X_1	9	$G_{16}X_5$	5	$G_{31}X_1$	10	$G_{47}X_1$	10
G_3X_2	8	$G_{16}X_5$	4	$G_{31}X_2$	6	$G_{47}X_2$	7
G_3X_3	7	$G_{17}X_1$	10	$G_{31}X_3$	1	$G_{47}X_3$	3
G_4X_1	5	$G_{17}X_2$	8	$G_{32}X_1$	10	$G_{48}X_1$	6
G_4X_2	8	$G_{17}X_3$	6	$G_{32}X_2$	5	$G_{48}X_2$	10
G_4X_3	9	$G_{17}X_4$	5	$G_{32}X_3$	1	$G_{49}X_1$	10
G_4X_4	4	$G_{17}X_5$	4	$G_{33}X_1$	2	$G_{49}X_3$	7
G_5X_1	2	$G_{18}X_1$	6	$G_{33}X_2$	10	$G_{49}X_3$	3
G_5X_2	3	$G_{18}X_2$	8	$G_{33}X_3$	2	$G_{50}X_1$	3
G_5X_3	6	$G_{19}X_1$	9	$G_{33}X_4$	0	$G_{50}X_2$	8
G_5X_4	8	$G_{19}X_2$	5	$G_{34}X_1$	10	$G_{50}X_3$	2
G_6X_1	9	$G_{19}X_3$	3	$G_{34}X_2$	2	$G_{51}X_1$	9
G_6X_2	7	$G_{19}X_4$	2	$G_{35}X_1$	10	$G_{51}X_2$	8
G_6X_3	6	$G_{20}X_1$	10	$G_{35}X_2$	2	$G_{51}X_3$	6
G_6X_4	3	$G_{20}X_2$	8	$G_{36}X_1$	10	$G_{51}X_4$	3
G_7X_1	9	$G_{20}X_3$	4	$G_{36}X_2$	3		
G_7X_3	7	$G_{21}X_1$	10	$G_{37}X_1$	10		
G_7X_3	4	$G_{21}X_2$	2	$G_{37}X_2$	2		
G_7X_4	2	$G_{22}X_1$	10	$G_{38}X_1$	10		
G_8X_1	2	$G_{22}X_2$	5	$G_{38}X_2$	6		
G_8X_2	5	$G_{22}X_3$	1	$G_{39}X_1$	8		
G_8X_3	6	$G_{23}X_1$	8	$G_{39}X_2$	3		
G_8X_4	8	$G_{23}X_2$	7	$G_{40}X_1$	10		
G_9X_1	10	$G_{24}X_1$	10	$G_{40}X_2$	2		
G_9X_2	4	$G_{24}X_2$	2	$G_{41}X_1$	10		
$G_{10}X_1$	6	$G_{25}X_1$	10	$G_{41}X_2$	2		
$G_{10}X_2$	10	$G_{25}X_2$	2	$G_{42}X_1$	10		
$G_{10}X_3$	8	$G_{26}X_1$	10	$G_{42}X_2$	4		
$G_{11}X_1$	3	$G_{26}X_2$	8	$G_{42}X_3$	1		
$G_{11}X_2$	5	$G_{26}X_3$	6	$G_{43}X_1$	7		
$G_{11}X_3$	8	$G_{27}X_1$	10	$G_{43}X_2$	6		
$G_{12}X_1$	10	$G_{27}X_2$	2	$G_{43}X_3$	8		
$G_{12}X_2$	2	$G_{27}X_3$	4	$G_{43}X_4$	10		
$G_{13}X_1$	10	$G_{28}X_1$	10	$G_{44}X_1$	6		
$G_{13}X_2$	7	$G_{28}X_2$	4	$G_{44}X_2$	7		
$G_{13}X_3$	0	$G_{29}X_1$	1	$G_{44}X_3$	9		
$G_{14}X_1$	10	$G_{29}X_2$	2	$G_{44}X_4$	2		

Appendix V- A
Score Used in the TQMI Model (Scale: 0 – 10) (Continued)

Processing Sector							
PR_1X_1	10	$PR_{18}X_1$	10	$PR_{34}X_1$	10	$PR_{53}X_1$	8
PR_1X_2	4	$PR_{18}X_2$	2	$PR_{34}X_2$	2	$PR_{53}X_2$	2
PR_1X_3	1	$PR_{18}X_3$	0	$PR_{35}X_1$	10	$PR_{54}X_1$	6
PR_2X_1	10	$PR_{19}X_1$	10	$PR_{35}X_2$	2	$PR_{54}X_2$	3
PR_2X_2	3	$PR_{19}X_2$	4	$PR_{36}X_1$	10	$PR_{55}X_1$	8
PR_2X_3	1	$PR_{19}X_3$	1	$PR_{36}X_2$	2	$PR_{55}X_2$	1
PR_3X_1	10	$PR_{20}X_1$	4	$PR_{36}X_3$	0	$PR_{56}X_1$	6
PR_3X_2	1	$PR_{20}X_2$	6	$PR_{37}X_1$	2	$PR_{56}X_2$	3
PR_4X_1	4	$PR_{20}X_3$	8	$PR_{37}X_2$	8	$PR_{57}X_1$	6
PR_4X_2	9	$PR_{21}X_1$	10	$PR_{38}X_1$	8	$PR_{57}X_2$	3
PR_4X_3	2	$PR_{21}X_2$	2	$PR_{38}X_2$	2		
PR_5X_1	10	$PR_{21}X_3$	0	$PR_{39}X_1$	10		
PR_5X_2	2	$PR_{22}X_1$	10	$PR_{39}X_2$	1		
PR_6X_1	10	$PR_{22}X_2$	2	$PR_{40}X_1$	10		
PR_6X_2	2	$PR_{22}X_3$	0	$PR_{40}X_2$	1		
PR_7X_1	4	$PR_{23}X_1$	10	$PR_{41}X_1$	10		
PR_7X_2	5	$PR_{23}X_2$	4	$PR_{41}X_2$	2		
PR_8X_1	6	$PR_{23}X_3$	2	$PR_{42}X_1$	10		
PR_8X_2	3	$PR_{24}X_1$	10	$PR_{42}X_2$	2		
PR_9X_1	10	$PR_{24}X_2$	5	$PR_{42}X_3$	0		
PR_9X_2	4	$PR_{24}X_3$	2	$PR_{43}X_1$	10		
PR_9X_3	0	$PR_{25}X_1$	10	$PR_{43}X_2$	2		
$PR_{10}X_1$	3	$PR_{25}X_2$	1	$PR_{44}X_1$	10		
$PR_{10}X_2$	9	$PR_{26}X_1$	10	$PR_{44}X_2$	2		
$PR_{11}X_1$	4	$PR_{26}X_2$	2	$PR_{45}X_1$	10		
$PR_{11}X_2$	10	$PR_{27}X_1$	10	$PR_{45}X_2$	2		
$PR_{11}X_1$	1	$PR_{27}X_2$	2	$PR_{46}X_1$	1		
$PR_{12}X_1$	10	$PR_{28}X_1$	4	$PR_{46}X_2$	10		
$PR_{12}X_2$	3	$PR_{28}X_2$	8	$PR_{47}X_1$	10		
$PR_{13}X_1$	10	$PR_{29}X_1$	10	$PR_{47}X_2$	2		
$PR_{13}X_2$	1	$PR_{29}X_2$	2	$PR_{48}X_1$	10		
$PR_{14}X_5$	10	$PR_{30}X_1$	10	$PR_{48}X_2$	2		
$PR_{14}X_1$	4	$PR_{30}X_2$	2	$PR_{48}X_3$	0		
$PR_{14}X_2$	0	$PR_{31}X_1$	5	$PR_{49}X_1$	8		
$PR_{15}X_3$	10	$PR_{31}X_2$	8	$PR_{49}X_2$	2		
$PR_{15}X_4$	4	$PR_{31}X_3$	10	$PR_{50}X_1$	1		
$PR_{15}X_5$	1	$PR_{32}X_1$	10	$PR_{50}X_2$	10		
$PR_{16}X_1$	10	$PR_{32}X_2$	3	$PR_{51}X_1$	10		
$PR_{16}X_2$	2	$PR_{33}X_1$	10	$PR_{51}X_2$	1		
$PR_{17}X_1$	9	$PR_{33}X_2$	4	$PR_{52}X_1$	10		
$PR_{17}X_2$	2	$PR_{33}X_3$	1	$PR_{52}X_2$	2		

Appendix V- A
Scores Used in the TQMI Model (Scale: 0 – 10) (Continued)

Energy Sector				Human Resource Sector			
$ENG_1 X_1$	1	$ENG_{16} X_1$	2	$HR_1 X_1$	1	$HR_{16} X_2$	5
$ENG_1 X_2$	2	$ENG_{16} X_2$	3	$HR_1 X_2$	10	$HR_{16} X_3$	8
$ENG_1 X_3$	4	$ENG_{16} X_3$	4	$HR_1 X_3$	4	$HR_{17} X_1$	1
$ENG_1 X_4$	6	$ENG_{16} X_4$	5	$HR_2 X_1$	8	$HR_{17} X_2$	4
$ENG_1 X_5$	10	$ENG_{16} X_5$	6	$HR_2 X_2$	5	$HR_{17} X_3$	8
$ENG_2 X_1$	4	$ENG_{17} X_1$	8	$HR_2 X_3$	3	$HR_{18} X_1$	10
$ENG_2 X_2$	10	$ENG_{17} X_2$	2	$HR_3 X_1$	1	$HR_{18} X_2$	2
$ENG_3 X_1$	8	$ENG_{18} X_1$	1	$HR_3 X_2$	10	$HR_{18} X_3$	1
$ENG_3 X_2$	10	$ENG_{18} X_2$	8	$HR_3 X_3$	4	$HR_{19} X_1$	10
$ENG_3 X_3$	0	$ENG_{19} X_1$	1	$HR_4 X_1$	10	$HR_{19} X_2$	2
$ENG_4 X_1$	7	$ENG_{19} X_2$	2	$HR_4 X_2$	6	$HR_{20} X_1$	10
$ENG_4 X_2$	9	$ENG_{19} X_3$	7	$HR_4 X_3$	2	$HR_{20} X_2$	0
$ENG_4 X_3$	5	$ENG_{19} X_4$	9	$HR_5 X_1$	1	$HR_{21} X_1$	10
$ENG_5 X_1$	10	$ENG_{20} X_1$	10	$HR_5 X_2$	10	$HR_{21} X_2$	5
$ENG_5 X_2$	6	$ENG_{20} X_2$	8	$HR_5 X_3$	4	$HR_{21} X_3$	2
$ENG_5 X_3$	8	$ENG_{20} X_3$	2	$HR_6 X_1$	1	$HR_{22} X_1$	10
$ENG_5 X_4$	0	$ENG_{21} X_1$	9	$HR_6 X_2$	10	$HR_{22} X_2$	2
$ENG_6 X_1$	10	$ENG_{21} X_2$	3	$HR_6 X_3$	5	$HR_{23} X_1$	2
$ENG_6 X_2$	1	$ENG_{22} X_1$	1	$HR_7 X_1$	10	$HR_{23} X_2$	8
$ENG_7 X_1$	10	$ENG_{22} X_2$	3	$HR_7 X_2$	6	$HR_{23} X_3$	7
$ENG_7 X_2$	6	$ENG_{22} X_3$	9	$HR_7 X_3$	2	$HR_{24} X_1$	1
$ENG_7 X_3$	1	$ENG_{23} X_1$	1	$HR_8 X_1$	10	$HR_{24} X_2$	10
$ENG_8 X_1$	10	$ENG_{23} X_2$	3	$HR_8 X_2$	5	$HR_{25} X_1$	10
$ENG_8 X_2$	6	$ENG_{23} X_3$	8	$HR_8 X_3$	1	$HR_{25} X_2$	3
$ENG_8 X_3$	2	$ENG_{24} X_1$	10	$HR_9 X_1$	10	$HR_{25} X_3$	0
$ENG_9 X_1$	9	$ENG_{24} X_2$	1	$HR_9 X_2$	5	$HR_{26} X_1$	10
$ENG_9 X_2$	7	$ENG_{25} X_1$	8	$HR_9 X_3$	1	$HR_{26} X_2$	5
$ENG_9 X_3$	2	$ENG_{25} X_2$	1	$HR_{10} X_1$	10	$HR_{26} X_3$	3
$ENG_{10} X_1$	9	$ENG_{26} X_1$	1	$HR_{10} X_2$	4	$HR_{27} X_1$	4
$ENG_{10} X_2$	7	$ENG_{26} X_2$	8	$HR_{10} X_3$	1	$HR_{27} X_2$	8
$ENG_{10} X_3$	2	$ENG_{26} X_2$	4	$HR_{11} X_1$	3	$HR_{27} X_3$	1
$ENG_{11} X_1$	9	$ENG_{27} X_1$	10	$HR_{11} X_2$	10	$HR_{28} X_1$	4
$ENG_{11} X_2$	7	$ENG_{27} X_2$	3	$HR_{11} X_3$	1	$HR_{28} X_2$	9
$ENG_{11} X_3$	2	$ENG_{28} X_1$	10	$HR_{12} X_1$	6	$HR_{28} X_3$	0
$ENG_{12} X_1$	9	$ENG_{28} X_2$	3	$HR_{12} X_2$	8	$HR_{29} X_1$	10
$ENG_{12} X_2$	7	$ENG_{29} X_1$	6	$HR_{12} X_3$	10	$HR_{29} X_2$	1
$ENG_{12} X_3$	2	$ENG_{29} X_2$	3	$HR_{13} X_1$	10		
$ENG_{13} X_1$	7	$ENG_{30} X_1$	10	$HR_{13} X_2$	4		
$ENG_{13} X_2$	9	$ENG_{30} X_2$	3	$HR_{13} X_3$	1		
$ENG_{13} X_3$	6	$ENG_{31} X_1$	10	$HR_{14} X_1$	10		
$ENG_{14} X_1$	9	$ENG_{31} X_2$	4	$HR_{14} X_2$	5		
$ENG_{14} X_2$	5	$ENG_{32} X_1$	10	$HR_{14} X_3$	2		
$ENG_{14} X_3$	1	$ENG_{32} X_2$	2	$HR_{15} X_1$	10		
$ENG_{15} X_1$	9	$ENG_{33} X_2$	9	$HR_{15} X_2$	7		
$ENG_{15} X_2$	5	$ENG_{33} X_3$	2	$HR_{15} X_3$	1		
$ENG_{15} X_3$	2			$HR_{16} X_1$	1		

Appendix V- A
Scores Used in the TQMI Model (Scale: 0 – 10) (Continued)

Maintenance Sector				Welfare Sector			
$MT_1 X_1$	8	$MT_{13} X_2$	1	$WEL_1 X_1$	10	$WEL_{12} X_2$	3
$MT_1 X_2$	6	$MT_{14} X_1$	10	$WEL_1 X_2$	9	$WEL_{13} X_1$	10
$MT_1 X_3$	3	$MT_{14} X_2$	3	$WEL_1 X_3$	5	$WEL_{13} X_2$	5
$MT_2 X_1$	10	$MT_{15} X_1$	10	$WEL_1 X_4$	1	$WEL_{13} X_3$	1
$MT_2 X_2$	1	$MT_{15} X_2$	5	$WEL_1 X_5$	0	$WEL_{14} X_1$	10
$MT_3 X_1$	10	$MT_{15} X_3$	3	$WEL_2 X_1$	7	$WEL_{14} X_2$	5
$MT_3 X_2$	3	$MT_{16} X_1$	10	$WEL_2 X_2$	9	$WEL_{14} X_3$	2
$MT_4 X_1$	10	$MT_{16} X_2$	5	$WEL_2 X_3$	1	$WEL_{15} X_1$	8
$MT_4 X_2$	1	$MT_{16} X_3$	2	$WEL_3 X_1$	10	$WEL_{15} X_2$	5
$MT_5 X_1$	8	$MT_{17} X_1$	10	$WEL_3 X_2$	8	$WEL_{15} X_3$	1
$MT_5 X_2$	3	$MT_{17} X_2$	5	$WEL_3 X_3$	1	$WEL_{16} X_1$	10
$MT_6 X_1$	10	$MT_{17} X_3$	1	$WEL_4 X_1$	10	$WEL_{16} X_2$	4
$MT_6 X_2$	5	$MT_{18} X_1$	10	$WEL_4 X_2$	1	$WEL_{16} X_3$	1
$MT_6 X_3$	2	$MT_{18} X_2$	5	$WEL_5 X_1$	10	$WEL_{17} X_1$	8
$MT_7 X_1$	1	$MT_{18} X_3$	1	$WEL_5 X_2$	3	$WEL_{17} X_2$	3
$MT_7 X_2$	3	$MT_{19} X_1$	10	$WEL_5 X_3$	1	$WEL_{18} X_1$	9
$MT_7 X_3$	10	$MT_{19} X_2$	5	$WEL_6 X_1$	10	$WEL_{18} X_2$	2
$MT_8 X_1$	1	$MT_{19} X_3$	1	$WEL_6 X_2$	3	$WEL_{19} X_1$	8
$MT_8 X_2$	2	$MT_{20} X_1$	10	$WEL_6 X_3$	1	$WEL_{19} X_2$	1
$MT_9 X_1$	10	$MT_{20} X_2$	5	$WEL_7 X_1$	10	$WEL_{20} X_1$	8
$MT_9 X_2$	5	$MT_{20} X_3$	1	$WEL_7 X_2$	1	$WEL_{20} X_2$	5
$MT_9 X_3$	1	$MT_{21} X_1$	8	$WEL_8 X_1$	10	$WEL_{20} X_3$	1
$MT_{10} X_1$	10	$MT_{21} X_2$	5	$WEL_8 X_2$	1	$WEL_{21} X_1$	10
$MT_{10} X_2$	1	$MT_{21} X_3$	3	$WEL_9 X_1$	10	$WEL_{21} X_2$	1
$MT_{11} X_1$	10	$MT_{22} X_1$	8	$WEL_9 X_2$	8	$WEL_{22} X_1$	10
$MT_{11} X_2$	1	$MT_{22} X_2$	4	$WEL_9 X_3$	3	$WEL_{22} X_2$	1
$MT_{12} X_1$	3	$MT_{22} X_3$	2	$WEL_9 X_4$	1	$WEL_{23} X_1$	10
$MT_{12} X_2$	5	$MT_{23} X_1$	10	$WEL_{10} X_1$	10	$WEL_{23} X_2$	1
$MT_{12} X_3$	4	$MT_{23} X_2$	1	$WEL_{10} X_2$	1	$WEL_{24} X_1$	10
$MT_{13} X_1$	10	$MT_{24} X_1$	10	$WEL_{11} X_1$	8	$WEL_{24} X_2$	3
		$MT_{24} X_2$	1	$WEL_{11} X_2$	4	$WEL_{25} X_1$	10
				$WEL_{11} X_3$	1	$WEL_{25} X_2$	5
				$WEL_{12} X_1$	10	$WEL_{25} X_1$	1

Appendix V- A
Scores Used in the TQMI Model (Scale: 0 – 10) (Continued)

Management Sector							
MAN_1X_1	10	MAN_9X_1	10	$MAN_{17}X_2$	5	$MAN_{26}X_1$	10
MAN_1X_2	3	MAN_9X_2	5	$MAN_{17}X_3$	2	$MAN_{26}X_2$	3
MAN_1X_3	1	MAN_9X_3	1	$MAN_{18}X_1$	10	$MAN_{27}X_1$	10
MAN_2X_1	10	$MAN_{10}X_1$	10	$MAN_{18}X_2$	4	$MAN_{27}X_2$	2
MAN_2X_2	3	$MAN_{10}X_2$	1	$MAN_{18}X_3$	1	$MAN_{28}X_1$	10
MAN_2X_3	1	$MAN_{11}X_1$	10	$MAN_{19}X_1$	10	$MAN_{28}X_2$	1
MAN_3X_1	10	$MAN_{11}X_2$	3	$MAN_{19}X_2$	4	$MAN_{29}X_1$	10
MAN_3X_2	3	$MAN_{11}X_3$	0	$MAN_{19}X_3$	1	$MAN_{29}X_2$	1
MAN_3X_3	1	$MAN_{12}X_1$	10	$MAN_{20}X_1$	10	$MAN_{29}X_3$	2
MAN_4X_1	10	$MAN_{12}X_2$	5	$MAN_{20}X_2$	3	$MAN_{30}X_1$	3
MAN_4X_2	3	$MAN_{12}X_3$	1	$MAN_{20}X_3$	1	$MAN_{30}X_2$	7
MAN_4X_3	1	$MAN_{13}X_1$	1	$MAN_{21}X_1$	1	$MAN_{30}X_3$	9
MAN_5X_1	10	$MAN_{13}X_2$	8	$MAN_{21}X_2$	6	$MAN_{30}X_4$	1
MAN_5X_2	3	$MAN_{14}X_1$	10	$MAN_{22}X_1$	1	$MAN_{31}X_1$	10
MAN_5X_3	1	$MAN_{14}X_2$	8	$MAN_{22}X_2$	6	$MAN_{31}X_2$	3
MAN_6X_1	1	$MAN_{15}X_1$	10	$MAN_{23}X_1$	8	$MAN_{31}X_3$	1
MAN_6X_2	6	$MAN_{15}X_2$	4	$MAN_{23}X_2$	4	$MAN_{32}X_1$	10
MAN_7X_1	10	$MAN_{15}X_3$	1	$MAN_{23}X_3$	2	$MAN_{32}X_2$	2
MAN_7X_2	4	$MAN_{16}X_1$	2	$MAN_{24}X_1$	7	$MAN_{33}X_1$	8
MAN_7X_3	1	$MAN_{16}X_2$	4	$MAN_{24}X_2$	5	$MAN_{33}X_2$	4
MAN_8X_1	10	$MAN_{16}X_3$	5	$MAN_{25}X_1$	10	$MAN_{33}X_3$	1
MAN_8X_2	5	$MAN_{16}X_4$	1	$MAN_{25}X_2$	5	$MAN_{34}X_1$	10
MAN_8X_3	2	$MAN_{17}X_1$	10	$MAN_{25}X_3$	1	$MAN_{34}X_2$	1
						$MAN_{35}X_1$	10
						$MAN_{35}X_2$	2

Appendix V- B

Scores for Base Factors Used In the TQMI Model (Scale: 0 – 10)

Factors	Score	Factors	Score
LTH_1	0	C_2	2
LTH_2	7	C_3	10
LTH_3	10	$LOCG_1$	10
$RFND_1$	0	$LOCG_2$	2
$RFND_2$	5	$LOCHO_1$	10
$RFND_3$	10	$LOCHO_2$	2
$RFJM_1$	0	PH_1	2
$RFJM_2$	5	PH_2	10
$RFJM_3$	10	PH_3	2
$ETMAX_1$	0	BD_1	10
$ETMAX_2$	5	BD_2	8
$ETMAX_3$	10	BD_3	6
$ETMIN_1$	0	BD_4	4
$ETMIN_2$	2	BD_5	2
$ETMIN_3$	10	$LAND_1$	10
C_1	0	$LAND_2$	0

Appendix V- C

Relative weightages for Attribute factors in the TQMI Model (Scale: 0 – 50)

Field Sector									
G_{1} W	18	G_{41} W	23	PR_{29} W	20	HR_{11} W	30	MAN_{21} W	30
G_{2} W	18	G_{42} W	30	PR_{30} W	10	HR_{12} W	40	MAN_{22} W	30
G_{3} W	17	G_{43} W	30	PR_{31} W	25	HR_{13} W	30	MAN_{23} W	25
G_{4} W	25	G_{44} W	30	PR_{32} W	12	HR_{14} W	30	MAN_{24} W	10
G_{5} W	25	G_{45} W	15	PR_{33} W	15	HR_{15} W	35	MAN_{25} W	30
G_{6} W	25	G_{46} W	20	PR_{34} W	12	HR_{16} W	25	MAN_{26} W	30
G_{7} W	25	G_{47} W	30	PR_{35} W	20	HR_{17} W	25	MAN_{27} W	25
G_{8} W	25	G_{48} W	45	PR_{36} W	25	HR_{18} W	25	MAN_{28} W	40
G_{9} W	25	G_{49} W	35	PR_{37} W	12	HR_{19} W	20	MAN_{29} W	20
G_{10} W	30	G_{50} W	5	PR_{38} W	15	HR_{20} W	50	MAN_{30} W	40
G_{11} W	30	G_{51} W	5	PR_{39} W	10	HR_{21} W	28	MAN_{31} W	25
G_{12} W	12	**Processing Sector**		PR_{40} W	15	HR_{22} W	45	MAN_{32} W	35
G_{13} W	15	PR_{1} W	25	PR_{41} W	17	HR_{23} W	20	MAN_{33} W	35
G_{14} W	15	PR_{2} W	15	PR_{42} W	40	HR_{24} W	40	MAN_{34} W	40
G_{15} W	20	PR_{3} W	17	PR_{43} W	20	HR_{25} W	20	MAN_{35} W	40
G_{16} W	25	PR_{4} W	15	PR_{44} W	10	HR_{26} W	20	**Welfare Sector**	
G_{17} W	25	PR_{5} W	10	PR_{45} W	20	HR_{27} W	20	WEL_{1} W	35
G_{18} W	12	PR_{6} W	15	PR_{46} W	15	HR_{28} W	18	WEL_{2} W	10
G_{19} W	20	PR_{7} W	8	PR_{47} W	15	HR_{29} W	35	WEL_{3} W	15
G_{20} W	25	PR_{8} W	8	PR_{48} W	30	**Management Sector**		WEL_{4} W	40
G_{21} W	15	PR_{9} W	17	PR_{49} W	18	MAN_{1} W	50	WEL_{5} W	25
G_{22} W	20	PR_{10} W	10	PR_{50} W	20	MAN_{2} W	25	WEL_{6} W	25
G_{23} W	20	PR_{11} W	15	PR_{51} W	15	MAN_{3} W	35	WEL_{7} W	40
G_{24} W	20	PR_{12} W	10	PR_{52} W	18	MAN_{4} W	45	WEL_{8} W	20
G_{25} W	20	PR_{13} W	15	PR_{53} W	25	MAN_{5} W	40	WEL_{9} W	35
G_{26} W	25	PR_{14} W	17	PR_{54} W	10	MAN_{6} W	40	WEL_{10} W	40
G_{27} W	35	PR_{15} W	12	PR_{55} W	10	MAN_{7} W	25	WEL_{11} W	20
G_{28} W	12	PR_{16} W	10	PR_{56} W	15	MAN_{8} W	15	WEL_{12} W	8
G_{29} W	12	PR_{17} W	15	PR_{57} W	10	MAN_{9} W	15	WEL_{13} W	15
G_{30} W	10	PR_{18} W	20	**Human Resource Sector**		MAN_{10} W	45	WEL_{14} W	25
G_{31} W	25	PR_{19} W	15	HR_{1} W	20	MAN_{11} W	20	WEL_{15} W	30
G_{32} W	25	PR_{20} W	20	HR_{2} W	25	MAN_{12} W	30	WEL_{16} W	15
G_{33} W	20	PR_{21} W	12	HR_{3} W	25	MAN_{13} W	30	WEL_{17} W	18
G_{34} W	20	PR_{22} W	15	HR_{4} W	30	MAN_{14} W	45	WEL_{18} W	29
G_{35} W	25	PR_{23} W	12	HR_{5} W	10	MAN_{15} W	40	WEL_{19} W	25
G_{36} W	28	PR_{24} W	14	HR_{6} W	20	MAN_{16} W	20	WEL_{20} W	15
G_{37} W	25	PR_{25} W	10	HR_{7} W	35	MAN_{17} W	22	WEL_{21} W	12
G_{38} W	20	PR_{26} W	12	HR_{8} W	20	MAN_{18} W	20	WEL_{22} W	18
G_{39} W	12	PR_{27} W	15	HR_{9} W	40	MAN_{9} W	20	WEL_{23} W	10
G_{40} W	28	PR_{28} W	12	HR_{10} W	30	MAN_{20} W	30	WEL_{24} W	25

Appendix V- C continued

Relative weightages for Attribute factors in the TQMI Model (Scale: 0 – 10)

$WEL_{25}W$	45	$ENG_{14}W$	40	$ENG_{29}W$	35	$MT_{11}W$	22
Energy Sector		$ENG_{15}W$	15	$ENG_{30}W$	20	$MT_{12}W$	18
$ENG_{1}W$	25	$ENG_{16}W$	20	$ENG_{31}W$	25	$MT_{13}W$	28
$ENG_{2}W$	25	$ENG_{17}W$	12	$ENG_{32}W$	25	$MT_{14}W$	40
				$ENG_{33}W$	35		
$ENG_{3}W$	15	$ENG_{18}W$	15	**Maintenance Sector**		$MT_{15}W$	25
$ENG_{4}W$	25	$ENG_{19}W$	20	$MT_{1}W$	22	$MT_{16}W$	20
$ENG_{5}W$	10	$ENG_{20}W$	10	$MT_{2}W$	30	$MT_{17}W$	25
$ENG_{6}W$	40	$ENG_{21}W$	18	$MT_{3}W$	45	$MT_{18}W$	18
$ENG_{7}W$	8	$ENG_{22}W$	25	$MT_{4}W$	22	$MT_{19}W$	15
$ENG_{8}W$	20	$ENG_{23}W$	20	$MT_{5}W$	24	$MT_{20}W$	10
$ENG_{9}W$	20	$ENG_{24}W$	10	$MT_{6}W$	30	$MT_{21}W$	10
$ENG_{10}W$	15	$ENG_{25}W$	20	$MT_{7}W$	50	$MT_{22}W$	10
$ENG_{11}W$	15	$ENG_{26}W$	40	$MT_{8}W$	20	$MT_{23}W$	10
$ENG_{12}W$	15	$ENG_{27}W$	25	$MT_{9}W$	25	$MT_{24}W$	35
$ENG_{13}W$	8	$ENG_{28}W$	10	$MT_{10}W$	14		

Appendix V- D

Maximum and Minimum Allotted Values for the Variable Factors

SPI	Variable	Maximum	Minimum
SPIG	RGETTE* (W $_{RGETTE}$ = 0.60)	RGETTE $_{MAX}$ = 0.40	RGETTE $_{MIN}$ = 0.25
	PPH** (W $_{PPH}$ = 0.40)	PPH $_{MAX}$ = 17500	PPH $_{MIN}$ = 12000
SPIPROC	RCON**	RCON $_{MAX}$ = 0.19	RCON$_{MIN}$ = 0.12
SPIENG	ETP*	ETP $_{MAX}$ = 10	ETP $_{MIN}$ = 2
SPIHR	TEHSPK*	TEHSPK $_{MAX}$ = 40	TEHSPK $_{MIN}$ = 25
SPIWEL	RWTE**	RWTE $_{MAX}$ = 0.30	RWTE $_{MIN}$ = 0.05
SPIMAINT	PEMAIN*	PEMAIN $_{MAX}$ = 0.30	PEMAIN $_{MIN}$ = 0.15
	BASE**	BASE $_{MAX}$ = 110	BASE $_{MIN}$ = 8

* 'Lower the Better Type' of Variable

** 'Higher the Better Type' of Variable

Appendix -VI -A

Algorithm for User Routing in Tea Information System

```
display startup menu
   get (option clicked)
   switch (option clicked)

display first  menu
   get (option clicked)
   switch (option clicked)

case click on picture: display welcome screen
   case about developers: display developers screen
   case exit:
   exit
            / WELCOME SCREEN INPUT HANDLING /
            display welcome screen
                        get (option clicked)
                        switch (option clicked)
                        case to main menu: display main_menu

            / DEVELOPERS SCREEN INPUT HANDLING /
            display developers screen
                        get (option clicked)
                        switch (option clicked)
                        case madhab c. bora: display mcb screen
                        case parimal bakul barua: display pbb screen
                        casc plabon Kakoti: display pk scrccn
                        case back: display welcome screen

                        / MCB SCREEN INPUT HANDLING /
                        display mcb screen
                                    get (option clicked)
                                    switch (option clicked)
                                    case return to previous menu: display developers screen

                        / PBB SCREEN INPUT HANDLING /
                        display pbb screen
                                    get (option clicked)
                                    switch (option clicked)
                                    case return to previous menu: display developers screen

                        / PK SCREEN INPUT HANDLING /
                        display pk screen
                                    get (option clicked)
                                    switch (option clicked)
                                    case return to previous menu: display developers screen

            / MAIN MENU INPUT HANDLING /
            display main_menu
                        get (option clicked)
                        switch (option clicked)
                        case home: display startup menu
                        case introduction: display objective screen
                        case status of tea industry: display status screen
                        case tea processing display processing screen
                        case health hazards of tea drinking: display hazards screen
                        case culture of tea tribe of assam: display culture screen
                        case tea vocabulary: display vocabulary screen
                        case the plan: display the plan screen
                        case origin and tea facts: display origin screen
                        case factors affecting tea quality: display factors screen
                        case system dynamics causality: display causality screen
                        case tea standards: display standard screen
                        case tea directory: run directory.exe
                        case tqmi of gardens: display tqmi screen

                        / OBJECTIVE SCREEN INPUT HANDLING /
                        display Introduction screen
```

get (option clicked)
switch (option clicked)
case home: display startup menu
case back: display main_menu

/ STATUS SCREEN INPUT HANDLING /
Display status screen
get (option clicked)
switch (option clicked)
case home: display startup menu
case main menu: display main_menu
case tea as a premier industry of assam: display premier screen
case recent scenario of tea industry in assam: display: recent screen

/ DISPLAY SCREEN INPUT HANDLING /
display display screen
get (option clicked)
switch (option clicked)
case back: display status screen

PREMIER SCREEN INPUT HANDLING
display premier screen
get (option clicked)
switch (option clicked)
case back: display status screen

PROCESSING SCREEN INPUT HANDLING
display processing screen
get (option clicked)
switch (option clicked)
case home: display startup menu
case main menu: display main_menu
case withering: display withering screen
case rolling: display rolling screen
case roll breaking and shifting: display roll_breaking_and_shifting screen
case fermentation: display fermentation screen
case firing and drying: display firing_and_drying screen
case grading and sorting: display sorting_and_ grading screen

/WITHERING SCREEN INPUT HANDLING/
display withering screen
get (option clicked)
switch (option clicked)
case back: display processing screen
case improper withering on processing: display improper_withering screen

/ IMPROPER_WITHERING DATA HADLING SCREEN /
display improper withering screen
get (option clicked)
switch (option clicked)
case back: display withering screen

/ROLLING SCREEN INPUT HANDLING/
display rolling screen
get (option clicked)
switch (option clicked)
case back: display processing screen

/ROLL BREAKING AND SHIFTING SCREEN INPUT HANDLING/
display roll_breaking_and_shifting screen
get (option clicked)
switch (option clicked)
case back: display processing screen

/FERMENTATION SCREEN INPUT HANDLING/
display fermentation screen
get (option clicked)
switch (option clicked)
case back: display processing screen
case development of quality: display quality_fermentation screen

QUALITY FERMENTATION SCREEN DATA HADLING
display quality_fermentation screen
get (option clicked)
switch (option clicked)
case back: display fermentation screen

/FIRING_AND_DRYING SCREEN INPUT HANDLING/
display firing_and_drying screen
get (option clicked)
switch (option clicked)
case back: display processing screen

/SORTING_AND_GRADING SCREEN INPUT HANDLING/
display sorting_and_grading screen
get (option clicked)
switch (option clicked)
case back: display processing screen

/ HAZARDS SCREEN INPUT HANDLING /
display hazards screen
get (option clicked)
switch (option clicked)
case back: display main_menu

/ CULTURE SCREEN INPUT HANDLING /
display culture screen
get (option clicked)
switch (option clicked)
case back to previous menu: display main_menu
case culture of tea tribes of assam: display culture_tea_tribe screen
case birth of tea in assam: display birth
case tea festivals: display festivals
case collection of songs: display songs
case marriage scene of tea tribe: display video_file_marriage
case jumur dance1: display video_file_dance1
case jumur dance 2: display video_file_dance2
case jumur dance 3: display video_file_dance3
case jumur dance 4: display video_file_dance4

/ CULTURE_TEA_TRIBE SCREEN INPUT HANDLING /
display culture_tea_tribe screen
get (option clicked)
switch (option clicked)
case return: display culture screen

/ BIRTH SCREEN INPUT HANDLING /
display birth screen
get (option clicked)
switch (option clicked)
case return: display culture screen

/ FESTIVALS SCREEN INPUT HANDLING /
display festivals screen
get (option clicked)
switch (option clicked)
case return: display culture screen

/ FESTIVALS SONGS SCREEN INPUT HANDLING /
display songs screen
get (option clicked)
switch (option clicked)
case return: display culture screen

/ VIDEO_FILE_MARRIAGE SCREEN INPUT HANDLING /
display video_file_marriage screen
run video_marraige
get (option clicked)
switch (option clicked)
case back to previous menu: display culture screen

```
/ VIDEO_FILE_DANCE1 SCREEN INPUT HANDLING /
display video_file_dance1 screen
        run video_dance1
        get (option clicked)
        switch (option clicked)
        case back to previous menu: display culture screen

/ VIDEO_FILE_DANCE2 SCREEN INPUT HANDLING /
display video_file_dance2 screen
        run video_dance2
        get (option clicked)
        switch (option clicked)
        case back to previous menu: display culture screen

/ VIDEO_FILE_DANCE3 SCREEN INPUT HANDLING /
display video_file_dance3 screen
        run video_dance3
        get (option clicked)
        switch (option clicked)
        case back to previous menu: display culture screen

/ VIDEO_FILE_DANCE4 SCREEN INPUT HANDLING /
display video_file_dance4 screen
        run video_dance4
        get (option clicked)
        switch (option clicked)
        case back to previous menu: display culture screen

/ VOCABULARY SCREEN INPUT HANDLING /
display vocabulary screen
        get (option clicked)
        switch (option clicked)
        case back: display main_menu

/ PLAN SCREEN INPUT HANDLING /
display plan screen
        get (option clicked)
        switch (option clicked)
        case back: display main_menu

/ ORIGIN SCREEN INPUT HANDLING /
display origin screen
        get (option clicked)
        switch (option clicked)
        case back to main menu: display main_menu
        / cases /
        case what is chai
        case ten virtues of tea
        case what is in the name
        case virgin tea
        case origin of tea in china
        case smouch
        case oldest tea bush
        case black tea
        case goddess of mercy
        case origin of tea in india
        case tea in europe
        case cricketers stroke
        case eisais kissa yojo ki
        case dual manufacture
        case tea room
        case instant/green/oolong tea
        case greatest tea maker
        case nimonah tea
        case origin of tea in japan
        case Darjeeling tea
        case tea tournament
        case nilgiri tea
        case japans tea history
```

```
                / ORIGIN SCREEN CASES INPUT HANDLING /
                        for case = 1 to 23
                           display (case)i screen
                                get (option clicked)
                                switch (option clicked)
                                case back: display origin screen
                           next i

/ FACTORS SCREEN INPUT HANDLING /
display factors screen
        get (option clicked)
        switch (option clicked)
        case back to main menu: display main_menu
        case home: display startup screen
        / cases /
        case genetic
        case environmental
        case leaf treatment
        case factory hygiene
        case manitenance
        case labour
        case processing

        / FACTORS SCREEN CASES INPUT HANDLING /
                for case = 1 to 7
                display (case)i screen
                        get (option clicked)
                        switch (option clickcd)
                        case back: display factors screen
                next i

/ CAUSALITY SCREEN INPUT HANDLING /
display causality screen
        get (option clicked)
        switch (option clicked)
        case back to main menu: display main_menu
        case home: display startup screen

        / cases /
        case withering
        case rolling
        case fermenting
        case drying
        case packaging
        case genetic
        case environmental
        casé leaf treatment
        case factory hygiene
        case manitenance
        case labour
        case processing

        / CAUSALITY SCREEN CASES INPUT HANDLING /
                for case = 1 to 12
                display (case)i screen
                        get (option clicked)
                        switch (option clicked)
                        case back: display causality screen
                next i

/ STANDARD SCREEN INPUT HANDLING /
display standard screen
        get (option clicked)
        switch (option clicked)
        casc back to main mcnu: display main_mcnu
        case disease control in tea: display disease_control screen
        case soil composition: display soil
        / other cases /
        case grades of employees
        case mandatory welfare activity
        case standard shade trees
        case tra certified clones
```

```
                case type of plantation
                case  pruning standards
                case standard tea population
                case pest control calendar
                case rejuvenation calendar
                / STANDARD SCREEN CASES INPUT HANDLING /
                        for case = 1 to 9
                        display (case)i  screen
                                get (option clicked)
                                switch (option clicked)
                                case back: display standard screen
                        next i

                / DISEASE_CONTROL SCREEN INPUT HANDLING /
                display disease_control screen
                        get (option clicked)
                        switch (option clicked)
                        case back: display standard screen
                        case diseases of tea: display disease_of_tea screen

                        / DISEASE_OF_TEA SCREEN INPUT HANDLING /
                        display disease_of_tea screen
                        get (option clicked)
                        switch (option clicked)
                        case back: display disease_control screen

                / SOIL SCREEN INPUT HANDLING /
                display soil screen
                        get (option clicked)
                        switch (option clicked)
                        case back: display standard screen
                        / cases /
                        case five principles of soil management
                        case fertility status
                        case soil pH for tea plantation
                        case soil bulk density for tea plantation

                        / SOIL SCREEN CASES INPUT HANDLING /
                        for case = 1 to 4
                        display (case)i  screen
                                get (option clicked)
                                switch (option clicked)
                                case back: display soil screen
                        next i

        / TQMI SCREEN INPUT HANDLING /
        display tqmi screen
                get (option clicked)
                switch (option clicked)
                case home: display startup menu
                case main menu: display main_menu
                case factors affecting tea quality: display factors screen
                case concept of tqmi: display concept screen
                case concept of sector performance indicator: display sectors screen
                case view classification of sectors: display sector_classification screen
                case energy sector: display energy_sector screen
                case computation of performance indicator of garden: run tqmi.exe

                / CONCEPT SCREEN INPUT HANDLING /
                display concept screen
                        get (option clicked)
                        switch (option clicked)
                        case back to previous menu: display tqmi screen
                        case view the sectors: display sector_classification screen
                        case area and scope of tqmi: display scope_tqmi screen

                        / SECTOR_CLASSIFICATION SCREEN INPUT HANDLING /
                        display sector_classification screen
                                get (option clicked)
                                switch (option clicked)
                                case back to previous menu: display concept screen
```

/ SCOPE_TQMI SCREEN INPUT HANDLING /
display scope_tqmi screen
get (option clicked)
switch (option clicked)
case back to previous menu: display concept screen

/ SECTOR S SCREEN INPUT HANDLING /
display sector screen
get (option clicked)
switch (option clicked)
case back to previous menu: display tqmi screen

/ SECTOR _CLASSIFICATION SCREEN INPUT HANDLING /
display sector_classification screen
get (option clicked)
switch (option clicked)
case back to previous menu: display tqmi screen

/ ENERGY_SECTOR SCREEN INPUT HANDLING /
display energy_sector screen
get (option clicked)
switch (option clicked)
case back to previous menu: display tqmi screen
case view energy consumption in tea processing: display energy_pattern screen

/ ENERGY_PATTERN SCREEN INPUT HANDLING /
display energy_pattern screen
get (option clicked)
switch (option clicked)
case back to previous menu: display energy_sector screen

/ OTHER CASES /
case human resource sector: display hr_sector screen
case processing sector: display processing_sector screen
case maintenance sector: display maint_sector screen
case management sector: display management_sector screen
case welfare sector: display wel_sector screen
case garden sector: display garden_sector screen

/ OTHER CASES OF TQMI SCREEN INPUT HANDLING /
for case = 1 to 6
display $(case)_i$ screen
get (option clicked)
switch (option clicked)
case back: display tqmi screen
next i

About the Author

The author of this thesis, *Plabon Kakoti,* was born on 5th September 1963. He received the degree of Bachelor of Engineering in Mechanical Engineering from Assam Engineering College, Guwahati, India, in the year 1986. He received the degree of Master of Technology in Industrial Engineering and Management from Indian Institute of Technology, Kharagpur, West Bengal, India, in 1992.

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