Trans. Inst. Indian Geographers
Vol. 25, Nos. 1&2, 2003

Determinants of Labour Productivity in Tea Cultivation in the Upper Brahmaputra Valley

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Abstract

The paper examines labour conditions of tea gardens prevailing in the areas of Upper Brahmaputra Valley where agro-ecological conditions, particularly the climate and soils are favourable for the growth of tea plants. The step-wise regression analysis reveals that labour productivity was greatly influenced by the land conditions rather than by the available labour force. However, unlimited supply of labour from the garden's population destabilizes the level of labour productivity. The diminishing rate of labour productivity varies in different agro-ecological conditions in the study area. Weak social amenities related to education and health and the high demographic pressure on the system of tea production in the gardens form the basis of low level of land productivity. Obliterated patterns evolving in the distribution of labour productivity in tea gardens show that the effects of market forces, transport costs and wage rates are major economic determinants of the spatial distribution of labour productivity in the Upper Brahmaputra valley.

Introduction

India has the unique distinction of being the largest producer as well as consumer of tea. The tea plantation developed in India over 150 years. It has colonial origins and it relates more to the factory than to the farm. During the 1990s, the production of tea in India rose from 688 million kg in 1989 to 805 million kg in 1999 (that was nearly 17.00%). This percentage was almost equal to the increase in world production (16.98%), during the same period. However, the increase in production was lower in Assam (i.e., 9.03%) as compared to India as a whole. As a result, the share of contribution of Assam to the national production has been shrinking steadily from 55.20% to 51.25% during the same period. It happened due to a much slower increase in yield and area under tea plantation than the country's figures (Table-1). Tea production has been gradually loosing its importance in the over all economy of Assam. Its growth is comparatively slower than the agricultural production in the state and, consequently, there is record decrease in the share of tea production to total GDP of the state from 44.41% (1953-54) to 8.64% (1998-99) (Daimari & Singh 2002).

There are many scientific studies and the reports of various commissions/committees on balanced development and self sustained growth of tea production. The scientists of Tocklai Experimental Station of tea cultivation, Jorhat have produced sufficient literature to determine the suitability of tea cultivation in relation to physiographic and geonomic aspects of tea estates by discussions highlighting onwards soil-fertility, climatic conditions and drainage systems of the gardens (Annual Scientific Report 1991-92, Grice 1971, Biswas 1971a, 1971b) and drawn even more intensive design of micro-element of soil fertility by conducting experiments on the effects of (i) available sulfur in the soils (Barbara and Sarma 1994) and (ii) the germination and duration of tea plants (Bera, Singh and Barbara 1994, Wood, et. al. 1964, Dey 1971, Bhattacharya and Singh 1994) on the tea plant yield.

On the other hand, the various improvements in the method of fields and factory operations were suggested by different commissions and groups constituted by the government agencies and Tea Plantation Enquiry Commission (1956). A working group on plantation crops in 1964, and Tea Finance Committee in 1964, were constituted to understand the problems of tea production and its export. The few scientific studies on the historical perspective of tea plantation and its structural changes, the optimal growth of tea production through the use of available technology and labour in the fields and factories (Misra 1979, 1986) and the 'technique efficiency' of production function for the tea gardens of Dooars (Dwibedi 1999, pp.98-100) were conducted to understand the optimal production (i.e., maximum expected yield) in the different combinations of production factors. Dwibedi (1999), concluded that (a) the larger size units are more efficient with respect to yield, (b) the older plants (more than 30 years old) produce higher output per bush than that of younger bush because of wider space area of older one having more plucking points to yield green leaves, and (c) the Gompertz growth follows the 'best fit' trend for optimising the time series data of tea production in the Dooars (Jalpaiguri and Coochbihar areas) of North-Bengal. On the whole, agro-ecological criteria of land suitability (Stamp 1962, Prasad, et. al. 1987, Singh 1994) and 'techno-economic' base as cited above have been studied for the enhancement of tea production. In the specific set of agro-ecological conditions, the efficiency of tea productivity is linked more with the socio-economic problems of population and families residing in the tea estates, which supply labour for the production activities (Awasthi 1975, Baruah 1981, Daimari 2003). There is a deficiency of literature on the labour productivity in tea cultivation, specially in Assam valley, where labour conditions are worse because of increasing population pressure, poor social amenities and the use of traditional technology in the fields and factories in the tea-estates.

Keeping these aspects of labour productivity in mind, a detailed analysis of the determinants of labour productivity and the conditions of labour supply in tea gardens is examined in the present research. The 'best-fit' method of regression analysis is used to isolate the effects of different labour productivity determinants. The productivity conditions have been interpreted with the help of 'classificatory' approach with the help of the concerned attributes, while distributional patterns of labour productivity are shown by preparing the isopleth map of the Upper Brahmaputra area with its different agro-ecological zones.

The Study Area

The physiographic attributes of land are equally important for the plant growth and

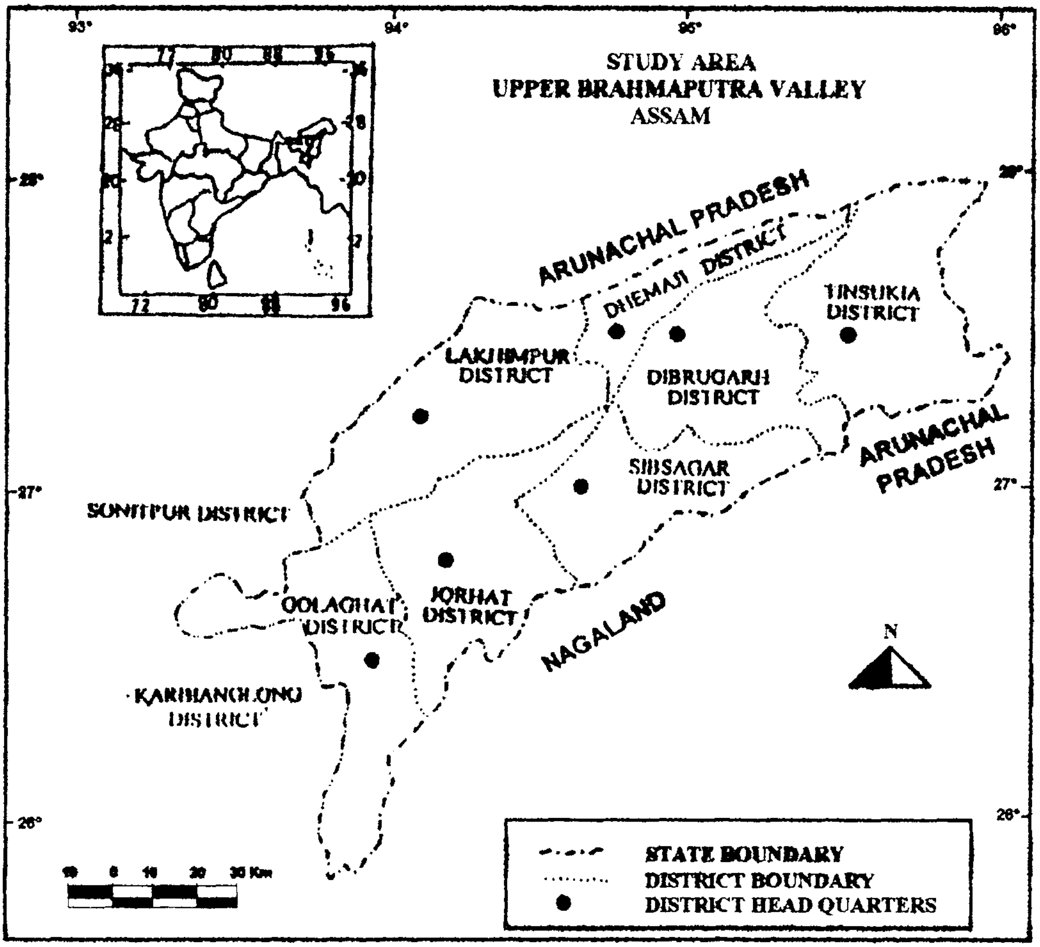

Fig. 1 **Location Map**

production of tea. Production and productivity conditions are interpreted by considering three different agro-ecological zones, so that the effect of physiographic as well as socio-economic attributes may be studied in detail. The Upper Brahmaputra valley, situated close to the Tropic of Cancer (25°12′ latitudes and 89°10′ to 96° 0′ E longtitudes), covers an area of about 21.67 lakh sq. km which is nearly one-third the area of the total Brahmaputra valley. It is formed by the new alluvial soils deposited and drained by the tributaries of Brahmaputra in its upper part where it comes down from the Arunachal Himalayas. It has well-defined physiographic units and comprises distinct relief features along the east-west axis where the tea gardens are located (Daimari, 2003 pp. 61-63). The northern boundary of the valley surrounded by the Himalayan foot hills, roughly touches the 150m contour. Its western boundary follows

225m contour while the northern and southern boundaries slope towards the flood plains of the river Brahmaputra. There are high terraces of boulders and pebbles in the *Tarai* and *Bhabar* areas of the older alluvial soils which are suitable sites for tea cultivation (Taher 1986). Favourable climatic conditions for which temperature, rainfall and evaporation are more influential elements and suitable soils for tea plant growth in which the moderate size of particles in topsoils with its highly acidic nature (3-5 pH) are major physiographic attributes which localize tea cultivation in this area (Daimari 2003, pp. 65-75). Three parallel agro-ecological zones: the Foot-hill, the Central Plain and the Flood Plain Zone are delineated to analyse the variations in labour productivity in the study area.

Labour Productivity Conditions

Production of tea or other crops from a particular piece of land is the result of the combined effects of various production factors like land (i.e., physical conditions of production), labour (demographic and social conditions) and technology (modern processing machines and capital). In order to isolate the effects of each factor, a number of statistical techniques and field survey designs have been adopted. The production function approach which is based on 'best-fit statistics' and the co-linearity technique which assigns weights to the factors/attributes in the form of 'eigen vectors', tracing the common traits, are the statistical inferences of factors' effect. Sometimes, co-linearity technique is not able to produce the results of the analysis to isolate the real effect of production factors either showing insignificant or weak degree of relationships among factors or because of the high association of unimportant attributes in the correlation matrix. On the other hand, field-observation techniques are based on sample designs and assumptions considered for the inference of 'real world situation'. For example, comparing similar agro-ecological conditions of tea gardens, the variations in productivity may be assumed because of differences in the supply of labour force, which is influenced by the socio-economic condition of population from where it is being supplied.

Considering three different agro-ecological conditions of the study area and classifying the total number of tea estates accordingly, the labour productivity has been interpreted as:

(a) The total registered area under tea estates has been estimated at 1,89,152 ha, which is even less than 1.0 % of the total geographical area of the Upper Brahmaputa valley (1994-95), with the total number of valley tea estates being 440, of different sizes, dispersed in different agro-ecological conditions. The distribution of registered tea area and labour percentage share is almost similar in all the agro-ecological conditions except for the production figures. The per garden average size of registered area as well as labour employed are also similar with moderate areal variations in the agro-ecological zones. About half the number of tea estates are concentrated in the Central fertile agro-ecological zone occupying 48.39 % of the total registered area under tea cultivation with a similar percentage share of labour engaged in tea production and a significantly much higher percentage share of its production (i.e., 51.17%) (Table2).

Table 1 **Changes in Area, Yield and Production of Tea (1989-1999)**

	Items	World	India	Assam Valley
(A)	Production (million kg)			
	1989	2503	688	380
	1999	2928	805	414
	Change	425	117	34
		(16.98%)	(17.00%)	(9.03%)
(B)	Area (ha)			
	1989	-	4,14,953	2,29,428
	1999	-	4,37,857	2,31,940
	Change	-	22,904	2,512
			(5.52 %)	(1.09%)
(C)	Yield (kg/ha)			
	1989	-	1658	1656
	1999	-	1840	1786
	Change	-	182	130
			(10.98 %)	(7.85 %)

It means that, in the central plains, the higher average yield (2210.13 kg/ha) has been recorded because of either more favourable agro-ecological conditions of tea growth or engagement of efficient workforce in the production of tea. As a result, labour productivity is also much higher (269 kg/person) in this part of fertile soils than the labour productivity of foot hills and flood plain ecology.

(b) Obliterated patterns of labour productivity, distribution and the isolated patches of high productivity are observed close to the main cities and growing towns, situated along the National Highway. It means that the market centers, which are absorption centres of rural labour as suppliers of tea production, influence the general pattern.

(c) However, areal patterns of two main attributes of tea cultivation: the tea crop yield and the labour productivity within the agro-ecological zones are diversified throughout; the co-efficient of areal variations of more than 100% for both the attributes are observed in all three zones. However, crop yield patterns are less diversified than the labour productivity patterns in the central plains. In fact, tea yield is more related to land conditions in the Assam valley (Daimari, 2003). It is an indication of less diverse agro-ecological conditions in which the more areal variations in labour productivity are revealed due to the diverse nature of labour intensity in its pattern (Table-2).

(d) The 'best-fit' analysis of labour productivity with three explanatory variables namely, yield, labour intensity and garden size shows that the power function, a log-log distribution, is best suited to show the suitable conditions of labour productivity in tea cultivation for which the coefficient of determinant (R^2) is found to be the highest (Table-3).

Table 2 **Production and Productivity of Tea Gardens in Different Agro-ecological Zones**

Agro-ecological Zones	No. of Gardens	Registered Area (ha)				Production (qu)				Labour available				Tea Yield (kg/ha)		Labour Productivity	
		Total	%	Average per garden	CV %	Total	%	Average per garden	CV %	Total	%	Average per garden	CV %	Total	CV %	Average kg/worker	CV %
Foot Hill Zone	83	39304	20.78	473.54	87.51	454729	17.48	5478	83.18	54480	20.48	656	93.11	1698	176.24	834	226.93
Central Plain Zone	218	91538	48.39	419.90	92.03	1330631	51.17	6103	94.66	125966	47.35	577	94.63	2210	156.66	1056	269.06
Flood Plain Zone	139	58310	30.82	419.50	86.40	815192	31.34	5864	118.45	85560	32.16	615	98.55	2031	168.43	952	267.73
Total	**440**	**189152**	**99.99**	**1312.94**	-	**2600553**	**99.99**	**5910**	-	**266006**	**99.99**	**605**	-	**2057**	-	**982**	-

Abbreviation: CV = Co-efficient of Variations

(e) A step-wise multiple regression analysis reveals that yield (i.e., indication of physical conditions of land) and labour intensity (i.e., related to labour conditions) are major determinants and complementary to each other because both contribute about 70.30% these to the labour productivity. In the present case, yield is a major determinant which contributes more than 50% to the productivity because, by definition, yield is the numerator of the fraction of labour productivity as **Pl=[(O/A)/(L/A)]** where **Pl=labour productivity, O=Total output, A=Cultivated area, L=Total, L=Total labour.**

Another fact which has emerged from the analysis is that the yield alone increases labour productivity at .54 times while the effects of yield together with labour intensity are observed marginally higher (as .58 times instead of .54) in the study area (Table-4). However, engagement of more labour in tea production activities diminishes the labour productivity. It may be because labour is not more efficient. The following are labour changes and available facilities in the gardens.

Labour productivity of tea gardens is influenced by the demographic as well as social amenities available in them. Gardens being a complete socio-economic unit in which the workers and their families are residing, has been arranging its labour force. According to the result of socio-economic survey of tea gardens conducted by Daimari (2003) for finding the facts of spatial variations in tea production and productivity, it is obvious that, in the productivity distribution, there is a concentration of the higher percentage share of tea garden (registered)

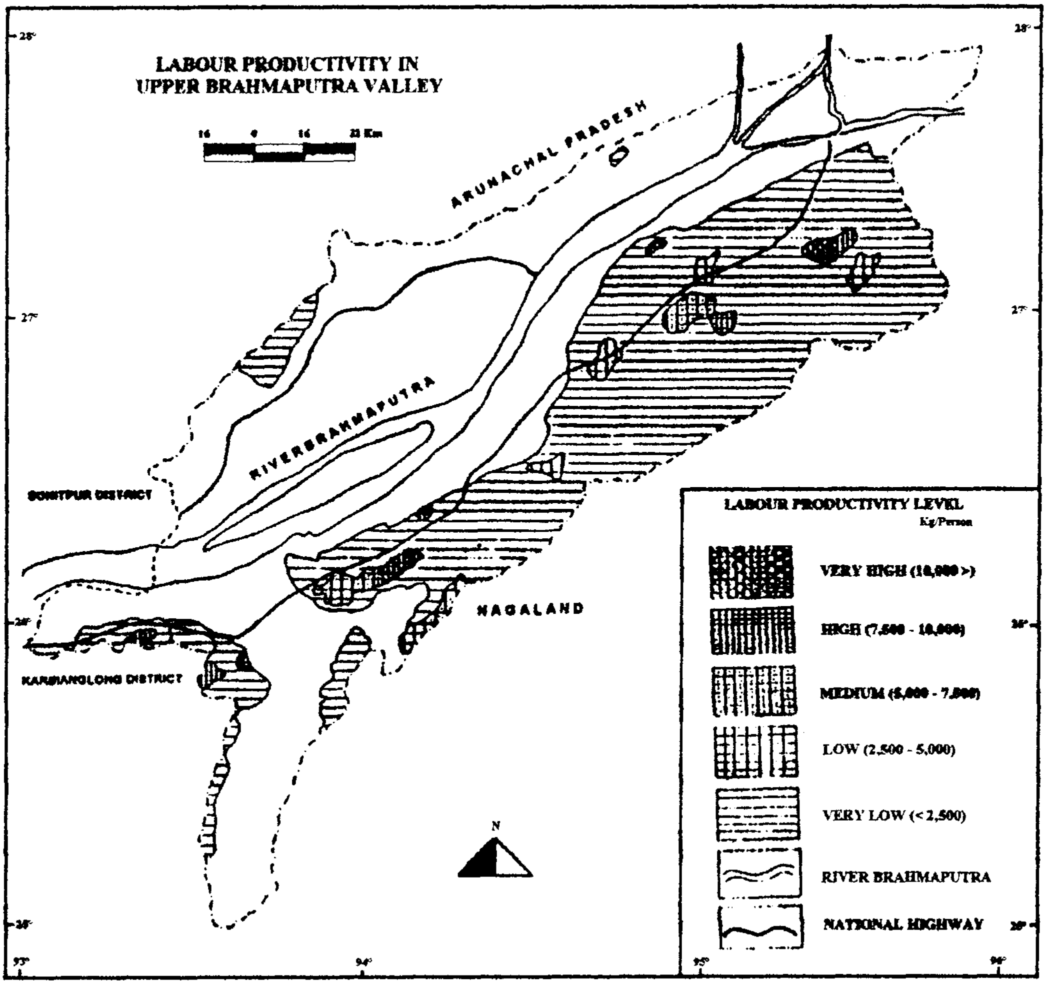

Fig. 2 **Distributional Pattern of Labour Productivity in Tea Garden**

area in the central part of the Upper Brahmaputra valley where a larger size of gardens, the higher concentration of population, and labour force are the reasons for low productivity. It means low labour productivity conditions prevail in the larger size of gardens in all the agro-ecological conditions. Density of population recorded is also very high (more than 279 persons/sq.km) in this category of very low productivity (below 1000 kg/persons) gardens. Even the density of population exceeds more than 358 person/sq.km in this category in the central plains. However, the dependency ratio is recorded higher than 1.0 in all ecological conditions. It means there is a burden of non-workers, specially child population on the work force (Table-5).

It may be possible that teenagers and children are also working/helping in plucking the tea leaves in the gardens of such low labour productivity and are considered in the

Table 3 **Regression Results of Labour Productivity (Y) with three Explanatory Variables (X) for Different Mathematical Functions**

Name of Functions	Labour Productivity vs Labour Intensity	Labour Productivity vs Yield	Labour Productivity vs Garden Size
Power	$Y = 2010.8\ X^{-0.8675}$ $R^2 = 0.2822$	$Y = 0.9171\ X^{0.9314}$ $R^2 = 0.6284$	$Y = 11619\ X^{-0.4084}$ $R^2 = 0.2194$
Exponential	$Y = 2731.7\ e^{-0.3941X}$ $R^2 = 0.2083$	$Y = 642.93\ e^{0.0002X}$ $R^2 = 0.4909$	$Y = 1701.7\ e^{-0.0009X}$ $R^2 = 0.1209$
Log	$Y = -2075.4Ln(X) +3226.9$ $R^2 = 0.2113$	$Y = 2139.9Ln(X) -14497$ $R^2 = 0.4339$	$Y =-1046.6Ln(X) +7812.6$ $R^2 = 0.1885$
Linear	$Y = -886.11x +3839.4$ $R^2 = 0.1378$	$Y = 0.548X +248.51$ $R^2 = 0.5051$	$Y = -2.0509X +2835$ $R^2 = 0.0921$

Table 4 **Step-wise Multiple Regression Showing Effects of Explanatory Variables on Labour Productivity**

Steps/Variables	b Coefficient	(t value)	Degree of Determinant R^2 (%)	Effect (%)
I Step:				
1. Yield	0.5479	(21.1440)	50.512	50.512
II Step:				
1. Yield	0.5826	(28.8417)	70.304	19.792
2. Labour Intensity	-1067.4482	(-17.0664)		
III Step:				
1. Yield	0.5725	(26.5895)	70.429	00.125
2. Labour Intensity	-1062.2163	(-16.9666)		
3. Garden Size	-0.25447	(-1.35474)		

labour category. More than 3.5 % workforce is child labour engaged in tea production activities in these very low productivity gardens, specially in the Flood plains and the Central plain areas (Daimari 2003). He interprets the situation and says that the higher population pressure supplies more labour to tea cultivation, sometimes, compel child labour in the gardens of low productivity where social amenities for the garden's population are weak. The larger part of the population (more than 1000 persons) is served by a doctor and a hospital staff in these gardens. Number of students per school as well as per teacher are higher than the national norms. Such weak infrastru-

Table 5 **Concentration of Population and Labour Force by Different Labour Productivity Classes**

Labour Productivity Classes (Kg/Worker)		No of Gardens	Registered Area (in ha) Avg/ garden	Total	%	Production (Kg) Avg/ garden	Total	%	Population Avg/ garden	Total	%	Labour (Total) Avg/ garden	Total	%	Dependency Ratio
FOOTHILL ZONE															
V Low	0-1000	49	587.08	28767.00	73.39	533196.41	26126624.00	58.06	1610.78	78928.00	70.40	873.20	42787.00	78.63	0.8447
Low	1001-2000	18	453.11	8156.00	20.81	723095.28	13015715.00	28.92	1684.11	30314.00	27.04	555.17	9993.00	18.36	2.0335
	2001-3000	5	200.60	1003.00	2.56	424122.20	2120611.00	4.71	263.40	1317.00	1.17	163.20	816.00	1.50	0.6140
	3001-4000	3	229.33	688.00	1.76	442165.00	1326495.00	2.95	227.33	682.00	0.61	135.33	406.00	0.75	0.6798
Medium	4001-5000	2	130.50	261.00	0.67	379725.50	759451.00	1.69	179.50	359.00	0.32	83.50	167.00	0.31	1.1497
	5001-6000	3	49.33	148.00	0.38	369547.67	1108643.00	2.46	138.67	416.00	0.37	64.33	193.00	0.35	1.1554
	6001-7000	0	107.00	0.00	0.00	474460.00	0.00	0.00	109.00	0.00	0.00	61.00	0.00	0.00	
High	7001-8000	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	8001-9000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	9001-10000	2	87.00	174.00	0.44	270490.50	540981.00	1.20	51.50	103.00	0.09	28.50	57.00	0.10	0.8070
V High	10001-Above	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
				39197.00	**100.00**		**44998520.00**	**100.00**		**112119.00**	**100.00**		**54419.00**	**100.00**	**1.0603**
CENTRAL PLAIN															
V Low	0-1000	104	485.75	50518.00	55.27	477521.16	49662201.00	36.90	1499.95	155995.00	53.94	770.70	80153.00	63.54	0.9462
Low	1001-2000	65	459.31	29855.00	32.66	782633.68	50871189.00	37.80	1741.78	113216.00	39.15	595.49	38707.00	30.68	1.9249
	2001-3000	9	479.78	4318.00	4.72	714758.44	6432826.00	4.78	783.44	7051.00	2.44	282.33	2541.00	2.01	1.7749
	3001-4000	9	202.00	1818.00	1.99	732840.67	6595566.00	4.90	714.00	6426.00	2.22	201.67	1815.00	1.44	2.5405
Medium	4001-5000	5	71.00	355.00	0.39	421971.80	2109859.00	1.57	151.40	757.00	0.26	97.20	486.00	0.39	0.5576
	5001-6000	8	118.88	951.00	1.04	441344.00	3530752.00	2.62	164.13	1313.00	0.45	81.13	649.00	0.51	1.0231
	6001-7000	2	960.50	1921.00	2.10	2370620.50	4741241.00	3.52	1041.50	2083.00	0.72	345.50	691.00	0.55	2.0145
High	7001-8000	2	134.50	269.00	0.29	291556.00	583112.00	0.43	104.50	209.00	0.07	37.50	75.00	0.06	1.7867
	8001-9000	6	127.00	762.00	0.83	948036.50	5688219.00	4.23	184.00	1104.00	0.38	108.00	648.00	0.51	0.7037
	9001-10000	2	113.50	227.00	0.25	568744.17	1137488.33	0.85	127.33	254.67	0.09	61.00	122.00	0.10	1.0874
V High	10001-Above	6	67.83	407.00	0.45	537981.17	3227887.00	2.40	130.83	785.00	0.27	44.50	267.00	0.21	1.9401
				91401.00	**100.00**		**134580340.33**	**100.00**		**289193.67**	**100.00**		**126154.00**	**100.00**	**1.2924**
FLOOD PLAIN															
V Low	0-1000	70	517.33	36213.00	62.45	524061.90	36684333.00	45.00	1442.54	100978.00	64.21	908.27	63579.00	74.31	0.5882
Low	1001-2000	33	452.09	14919.00	25.73	670829.64	22137378.00	27.16	1292.91	42666.00	27.13	502.39	16579.00	19.38	1.5735
	2001-3000	11	217.82	2396.00	4.13	386208.00	4248288.00	5.21	273.73	3011.00	1.91	165.45	1820.00	2.13	0.6544
	3001-4000	7	253.71	1776.00	3.06	458520.00	3209640.00	3.94	250.86	1756.00	1.12	131.00	917.00	1.07	0.9149
Medium	4001-5000	9	162.89	1466.00	2.53	506421.67	4557795.00	5.59	637.56	5738.00	3.65	112.22	1010.00	1.18	4.6812
	5001-6000	2	358.50	717.00	1.24	3739427.50	7478855.00	9.17	1001.00	2002.00	1.27	677.00	1354.00	1.58	0.4786
	6001-7000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
High	7001-8000	3	72.67	218.00	0.38	372673.00	1118019.00	1.37	98.00	294.00	0.19	49.33	148.00	0.17	0.9865
	8001-9000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	9001-10000	1	28.00	28.00	0.05	406836.00	406836.00	0.50	556.00	556.00	0.35	42.00	42.00	0.05	12.2381
V High	10001-Above	3	85.67	257.00	0.44	559360.33	1678081.00	2.06	83.67	251.00	0.16	37.00	111.00	0.13	1.2613
				57990.00	**100.00**		**81519225.00**	**100.00**		**157252.00**	**100.00**		**85560.00**	**100.00**	**0.8379**

ctural conditions produce the traditional unskilled low-paid labour which stabilises the production in the gardens and diminishes labour productivity. As a result, labour productivity diminishes as labour intensity is increased in the production system in all agro-ecological conditions in the Upper Brahmaputra valley.

Concluding Remarks

Areal differentiations in agro-ecological conditions differentiate the level of labour productivity in tea cultivation. Yield and labour intensity, which are major explanatory variables of labour productivity, determine its level. Yield of tea is more related to agro-ecological conditions and has direct impact on labour productivity while labour intensity is inversely related to it and influenced by the conditions of available labour and its family conditions. The following few important conclusions have been drawn from the present analysis:

1) The obliterated pattern of isolated patches of high labour productivity are observed. These high productivity areas are located very close to the main cities and along National Highways because of the effect of market forces. The study of the spatial structure of tea garden economy may help to understand the impact of market factors on the improvement of labour conditions and productivity in tea cultivation.

2) Physical conditions of land are major determinants of labour productivity in the Upper Brahmaputra valley. However, labour intensity is complementary to the enhancement of tea-yield upto a certain extent. The more intensified labour operations in tea cultivation destabilises the level of labour productivity.

3) A double-log distribution of labour productivity with the explanatory variables predicts a fast increase in productivity, which may be retained in future if land management and proper facilities for the labour residing in the gardens are provided. This distribution follows Cobb-Douglas production function, which is also suitable to predict the agricultural production in Assam (Borbora & Mahanta 2001).

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