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A Study on the Impact of Climate Change on the Productivity and Women Employment in Coffee and Tea Plantations in India

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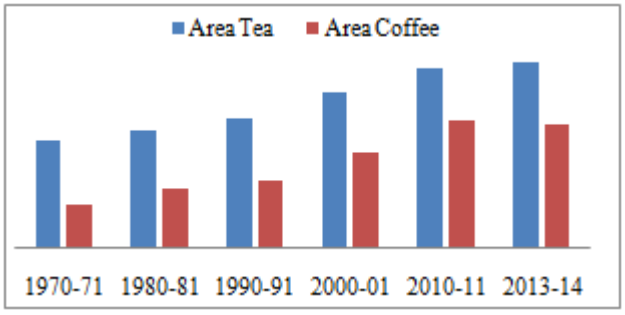
Abstract: ***Whilst climate change is one among the many external factors which affects the crop production in general, it must also be acknowledged that the recent studies on climate change indicate that among all the external factors it surely is a factor which cannot be ignored due to its prominent effect on the crop yield. One of the many sub sectors within agriculture which is directly affected by changing climate which also forms the backbone of agriculture sector in India is the plantation sector. Among the many crops in the sector, coffee and tea are highly export oriented crops and also labour intensive crops. The growth of this sector has significant linkages to other sectors as well. One of the linkages would be increased living standards through employment generation. The plantation sector employs more than 2 million workers in the country. And out of the total labour employed, 54 percent comprise of women. This paper analyses two objectives- firstly studies the relation between climate change and yield, secondly it studies the relation between yield and women employment in the sector. The time frame considered for the study is 1970 to 2014, while for labour and yield 1995 to 2011 is considered. Ordinary Least Square regression is used to study the relation. The results show temperature affects both tea and coffee yield. This in turn has an effect on the employment of women in tea and coffee plantations.***

Keywords: Climate Change, Tea, Coffee, Women Employment, Linkage Effect

1. Introduction

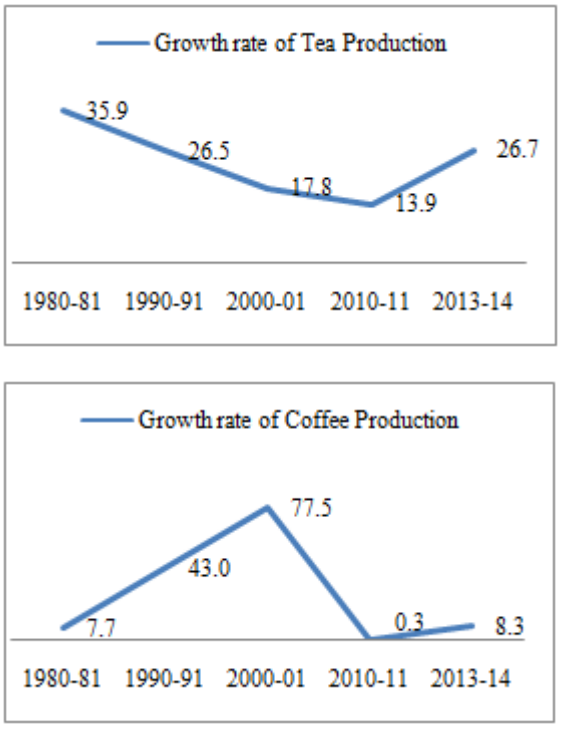
Whilst climate change is one among the many external factors which affects the crop production in general, it must also be acknowledged that the recent studies on climate change indicate that among all the external factors it surely is a factor which cannot be ignored due to its prominent effect on the crop yield. One of the many sub sectors within agriculture which is directly affected by changing climate is the plantation sector.

Plantation crops in India being coffee, tea, spices, coconut, arecanut, rubber to mention a few forms the backbone of agriculture sector. These crops are essentially high value commercial crops which have a significant economic importance. It also ensures the transition of an Indian agrarian economy to market oriented commercial cultivation due to its trade significance. Of the many plantation crops coffee and tea are the most produced and exported plantation crops. The area, of tea and coffee has shown an increasing trend as seen in the graph 1.1 below. But the increase is very marginal.



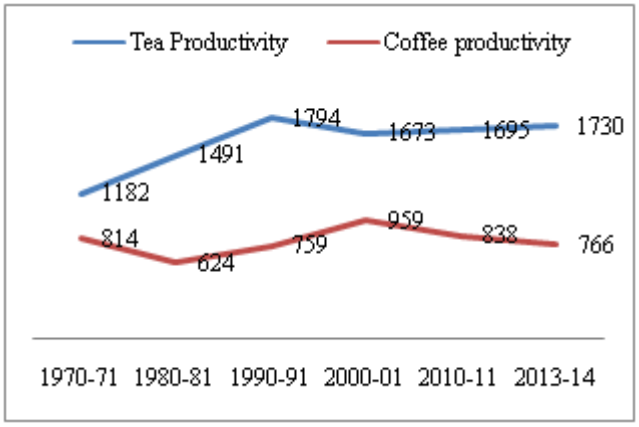
Graph 1.1: Production area of Coffee and Tea in India (million hectares)
Source: Coffee board of India reports and Tea Board of India Reports

However the production of both coffee and tea has shown an erratic trend. The growth rate of coffee and tea production in India has been shown in the graph 1.2 below where initially the trend shows increasing for coffee production but later starts declining rapidly. In case of tea production the trend is rather declining throughout.



Graph 1.2: Growth rate of tea and coffee production in India.
Source: Coffee board of India reports and Tea Board of India Reports

The more accurate indicator to measure the performance of both the crops is the Yield per hectare which measures the productivity of both coffee and tea. The graph 1.3 below shows the productivity trends of coffee and tea which is rather disappointing. The productivity of both the crops do not show any significant increase though the both the crops are export-oriented crops.



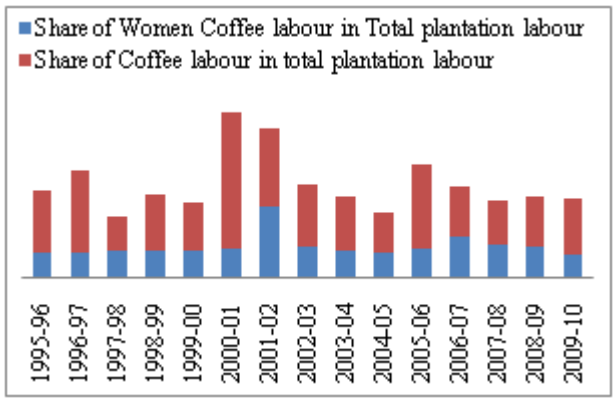
Graph 1.3: Productivity trends of Tea and Coffee in India (in million kgs)
Source: Coffee board of India reports and Tea Board of India Reports

The development of the plantation sector is crucial for an economy's external sector due to its increasing demand in the global market. Also the growing importance of the sector in the daily life of the people can be gauged by increasing weight assigned to products directly linked to the plantation sector while calculating WPI in India. (The weight assigned for the products directly linked to the plantation crop sector has increased by 12.1 per cent for base year 2004-05)[4].

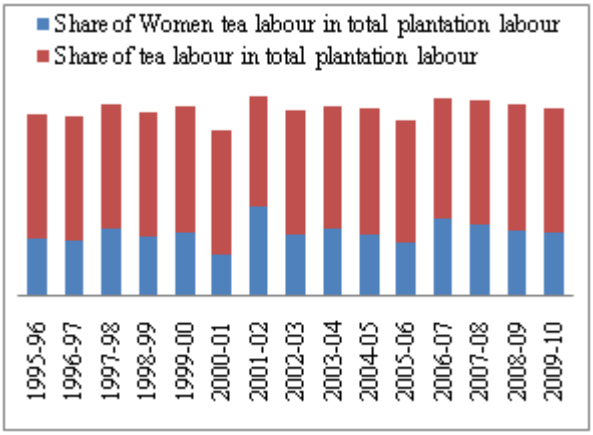
It must be noted that the plantation sector is one of the major source of foreign exchange earning to the economy. Considering only tea and coffee- in the year 2013-14 the value of coffee exported was 793 million USD and that of tea exports was 747 million USD. India stands second in terms of global tea production with a share of 24.9 percent next to China and account for 12 percent of world tea exports. In case of coffee, India stands seventh largest producer in the world. The share of India's coffee production to world production is 3.7 percent and its share in global trade is 2.7 percent. Though the share of Indian coffee in global exports is less it has seen an increasing trend between 2007-08 and 2011-12 with a growth rate of 13.8 percent per annum.

Often plantation sector is seen just as a foreign exchange earner neglecting its importance in achieving inclusive growth strategy due to its role in employment generation (especially of women), ensuring livelihood of small, marginal and backward communities. The growth of this sector has significant linkages to other sectors as well. One of the linkages would be through increased living standards through employment generation. The plantation sector employs more than 2 million workers in the country. According to the study on Socio-economic conditions of women workers in plantation industry- 2008-09, about one lakh workers are engaged in coffee production and about eight lakh in tea production. And out of the total labour employed, 54 percent comprise of women.It must also be remembered that the sector not only provides direct employment in the farm through tea leaves and coffee beans plucking but also provides indirect employment due to its extensive post-harvest processing and value addition. This shows the gender bias in the plantation sector where more than half of the labour force employed is women.

If we consider coffee and tea plantation women labour then the graph 1.4 and 1.5 below shows a declining trend.



Graph 1.4: Share of Women coffee labour in Total Plantation labour
Source: Author's calculation using Coffee board of India reports and Tea Board of India Reports



Graph 1.5: Share of Women Tea labour in Total Plantation labour
Source: Author's calculation using Coffee board of India reports and Tea Board of India Reports

The main reason attributed to the decline in the share of labour (men and women together) is the decline in the production of both coffee and tea over the years due to changes in temperature and erratic season less rainfall. Also men employed in the plantation sector have migrated out in search of jobs especially in the construction sector which offers a better pay thereby leaving a further vacuum in the labour supply of plantation sector. It is also been found in a study done by Rajasenan et.al[2] that successful implementation of MGNREGA scheme which guarantees 100 days employment to farming labour during off season time with a decent pay has resulted in labour migrating out of Tamil Nadu to their native places. This further aggravates labour shortage problem in already labour dearth labour intensive plantation sector.

As seen from the graphs 1.1 and 1.2 above the production of both coffee and tea, especially 2002 onwards have had a set-back due to unpredictability in the temperature and rainfall. This unpredictability has indeed caused a matter of concern for the farmers since the cost of growing the crop has gone up due consequences of climate change such as erosion of top soil, pest influx, dilution in flavour etc. This increased cost cannot be reflected in the prices of coffee and tea due to their market competition.

Literature indicates that the global climate change has been occurring for the past decades and the increase in Green House Gases has shown its impact on climate such as rising seasonal temperature, excessive rainfall at a time with prolonged dry period, pattern-less rainfall trend. Plantation sector is highly sensitive to changes in climate especially to changes in temperature. Coffee and tea plantations require hot and humid climate with temperature varying between 15 degree Celsius to 28 degree Celsius and rainfall between 150 – 250 cm. Research studies suggest the impact of climate change observed through the previous decade on plantation crops – coffee and tea, has had an adverse effect not only the quantity of the produce but also on the quality of the produce. This adverse effect on produce directly links to the related effects in the employment potential (esp. women employment) of the sector.

This raises certain researchable questions – what is the impact of rising temperature on the yield per hectare of these crops? Is temperature a more important climate related variable affecting the produce or is it rainfall? How is production of these crops related to employment in the sector? Since the majority of labour employed in the sector are women, what impact will the reduction in yield have on women's employment? What could be other related climate variables affecting the yield?

In an effort to fill the identified research gaps, this paper attempts to study the following **objectives**:

a) To study the relationship between women labour employed in coffee and tea plantations and the yield per hectare of coffee and tea (separately).
b) To study the relationship between yield per hectare of coffee and tea (separately) and temperature.

2. Time Period and Data

The time period chosen for the study is from 1970-71 to 2013-14. To analyse the relation between labour and yield the time period considered is from 1995-96 to 2010-11. The data for the study is taken from Labour Bureau of India, Coffee Board of India, Tea Board of India.

3. Methodology

The variables chosen to represent climate change are annual mean temperature and annual mean rainfall.
For Productivity of tea and coffee – Yield per hectare of tea and coffee are chosen.
For labour – Average daily employment of women in coffee and tea plantations is chosen

Apart from Line graph, trend linesused for pictorial representations, to study the correlation between variables– Karl Pearson's Correlation statistic is used. OLS regression is performed using the software STATA to study the degree of relationship between the variables. The model is tested to conform to the Gauss-Markov assumptions.

4. Review of Literature

James Bilham (2011) found that temperature had more effect on crop yield than precipitation. Also says temperature thresholds which severely affect yield outputs may already have been reached.

Battisti, Naylor (2009) in a study Prolonged hot summer in Ukraine and southwest Russia in 1972, with temperature anomalies of 2-4^{0}C over long term mean caused a 1.3% decline in wheat production in a highly producing region.

Schlenker and Roberts (2009) – The mean temperature is an important parameter for crop yield. The increased occurrence of extreme climatic events, such as non-linear temperature effects is likely to overshadow changes in mean temperatures and their impact upon yield.

Conway (2009) – Many crops already grow close to their tolerance limits and few days of extreme temperature can seriously affect yields.

Wheeler et al (2000) – shows importance of temperature variability in crop yields.

5. Summary of Results

The correlation results in the table 1.1 below shows a positive strong correlation between yield per hectare of tea and temperature. In case of coffee yield and temperature there appears to be a strong positive correlation as well.

Table 1.1: Karl Pearson's Correlation Matrix

	Annual Mean Temperature	Annual Mean Rainfall	Annual Average Women Employment
Coffee Yield per hectare	0.57	-0.18	0.53
Tea Yield per hectare	0.61	0.06	0.53

Source: Author's calculation using data from Coffee and Tea Board of India, Labour Bureau of India

However the correlation between coffee yield and rainfall showed a low negative correlation while that for tea showed a low positive correlation, indicating rainfall is an important factor affecting the yield of coffee and tea. The correlation result shows a strong positive association between yield per hectare of coffee and women employment in plantation sector. Same was in the case for yield per hectare of tea and women employment in tea plantations. In order to understand the degree of relation between the variables considered for study an Ordinary Least Square regression is performed using STATA software.

5.1 Coffee Yield and Temperature

Firstly simple linear regression was performed between Coffee yield per hectare and annual mean temperature. The model used can be written as:
$C_y = \alpha+\beta\ T+e$
Where C_y = Yield per hectare of Coffee;
α= Constant;
β = Regression Coefficient;
T = Annual Mean Temperature
e= Error component

The β coefficient after the regression was run was 0.06 with an R^2 of 0.32 which means temperature explains 32% of the variance in Coffee yield. The t-value was 4.76 which suggests temperature is an important variable which explains variations in Coffee yield. P-value being 0.000 shows temperature is statistically significant in explaining coffee yield. The model suggests a one percent increase in temperature leads to a 0.06 percent increase in the coffee yield. The model has been tested and conforms with the assumptions of Gauss-Markov model.

5.2 Tea Yield and Temperature

The model used can be written as:
$TE_y = \alpha+\beta\ T+e$
Where TE_y = Yield per hectare of Tea;
α= Constant;
β = Regression Coefficient;
T = Annual Mean Temperature
e= Error component

The β coefficient after the regression was run was 5.75 with an R2 of 0.38 which means temperature explains 38% of the variance in Tea yield. The t-value was 5.52 which suggests temperature is an important variable which explains variations in Coffee yield at 95% confidence. P-value being 0.000 shows temperature is statistically significant in explaining tea yield. The model suggests a one percent increase in temperature leads to a 5.75 percent increase in the tea yield. The model has been tested and conforms with the assumptions of Gauss-Markov model.

The model also included rainfall variable to see the effect on productivity, however the variable did not show significant result. Though rainfall is an important variable theoretically yet it did not show significance statistically. The reason for the same is beyond the scope of this paper and calls for further research on the same.

5.3 Women Employment and Coffee Yield

The model used can be written as:
$WC = \alpha+\beta C_y +e$
Where WC = Annual Average Women Employment in Coffee Plantations
α = Constant;
β = Regression Coefficient;
C_y = Yield per hectare of Coffee;
e = Error component

The β coefficient after the regression was run was 1.27 with an R^2 of 0.30 which means Coffee yield explains 30% of the variance in Average Women Employed in Coffee plantation. The t-value was 2.75 which suggests Coffee Yield is an important variable which explains variations in women employed in the coffee plantations at 95% confidence. P-value being 0.016 shows Coffee yield is statistically significant in explaining Women Employment in the sector.

The model suggests a one percent increase in coffee yield leads to a 1.27 percent increase in the women employed in the coffee plantation sector. The model has been tested and conforms with the assumptions of Gauss-Markov model.

5.4 Women Employment and Tea Yield

The model used can be written as:
$WT = \alpha+\beta TE_y +e$
Where WT = Annual Average Women Employment in Tea Plantations
α = Constant;
β = Regression Coefficient;
TE_y = Yield per hectare of Tea;
e = Error component

The β coefficient after the regression was run was 2.75 with an R^2 of 0.28 which means Tea yield explains 28% of the variance in Average Women Employed in Tea plantation. The t-value was 2.50 which suggesting Tea Yield is an important variable which explains variations in women employed in the Tea plantations at 95% confidence. P-value being 0.02 shows Tea yield is statistically significant in explaining Women Employment in the sector. The model suggests a one percent increase in tea yield leads to a 2.75 percent increase in the women employed in the tea plantation sector. The model has been tested and conforms with the assumptions of Gauss-Markov model.

6. Conclusion

The results above suggest that temperature affects both tea and coffee yield. This in turn has an effect on the employment of women in tea and coffee plantations. Thus climate change has to be considered as an important variable when formulating policies in the plantation sector.

The current policies concerning plantation sector focuses more increasing the yield and neglects the importance of labour involved in the sector. The Act concerning plantation sector in India dates back to 1951 without amending it since then. There is an urgent need to amend the act to relate it to the changed situation. Secondly in the area of trade with other economies, consideration must be given to exemptions to labour-intensive plantation crops before entering into Preferential and Free Trade agreements as global competition for such crops are cut-throat. Thirdly since tea and coffee prices are determined based on global demand and supply forces, in order to avoid global price shocks a corpus fund for price stabilisation must be created by the government so that the wages paid to the labour esp. women labourers do not get affected. As mentioned previously the sector faces labour shortages due to migration of labour to others lucrative sectors- to avoid this productivity linked

wage system must be introduced. Lastly the current global environment is being assessed on the basis of carbon footprint i.e amount of carbon emitted during the process of production. Currently in India, tea and coffee products are not being assessed with respect ot carbon footprint. Hence there is a need to assess the same to ensure environmental sustainability in the cultivation and processing process.

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