# EXPERTS' OPINIONS ON THE IMPACT OF CLIMATE CHANGE ON TEA CULTIVATION IN SRI LANKA

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## INTRODUCTION

Changes in temperature, rainfall, and extreme weather events have had a negative impact on the tea sector (Herath and Weersink, 2009). Drought conditions can reduce both the quantity and quality of tea harvests, while its quality is significantly affected by the duration and intensity of rainfall resulting in significant losses in tea export earnings (Gunathilaka *et al*., 2018). It is crucial to evaluate the potential impact of climate change on tea productivity and to propose appropriate adaptation methods to mitigate any adverse effects (Wijeratne *et al*., 2007). Further, it is significantly important in taking necessary actions to adapt to climate change and mitigation strategies (Navaratne *et al*., 2019). Although there is research done to propose suitable adaptation measures to minimize climate's adverse effects, they do not include a comparison between the perceptions of different tea expert communities on the impacts of the climate on tea cultivation. Since there is a lack of coordination and proper direction of implementation of climate change adaptation measures in Sri Lanka, it is particularly important to have strong leadership and guidance from the top management level (De Costa, 2010). Therefore, this study focuses on the comparison of perception among different tea expert communities i.e., academics, executives and estate managers and evaluates whether there is any significant difference prevailing among the perceptions on climatic impact over Sri Lankan tea cultivation among three expert groups, which would tangibly affect production and productivity of the tea sector in short and long term.

## METHODOLOGY

### *Study Area*

The research was conducted representing the entire Sri Lankan tea growing areas including up-country, mid-country and low country.

### *Data collection*

Purposive sampling method was used to select a sample of 41 respondents, representing 25 tea estate managers, 10 tea sector corporate executives and 6 tea related academia. Primary data were collected through key informant interviews using a semi structured questionnaire. The questionnaire focused on capturing the perception of experts on 10 climatic and soil factors which affect tea cultivation which were selected based on existing literature.

### *Data Analysis*

The Analytical Hierarchy Process (AHP) technique (Saaty, 2008) was used to rank suitability factors for tea cultivation. Primary data were collected from the respondents using ranks from 1 to 9 according to the scale. (Table 1). A nine-point scale is proposed to have a pair-wise comparison of different components, as depicted in equation (1).

$$M = (a_{ij}) = \begin{matrix} \\ D_1 \\ D_2 \\ \vdots \\ D_n \end{matrix} \begin{pmatrix} D_1 & D_2 & \dots & D_4 \\ 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ .. & .. & .. & .. \\ 1/a_{1n} & 1/a_{2n} & .. & 1 \end{pmatrix} \text{.........(1)}$$

Where, M=pair-wise comparison matrix, $D_i$=criteria and $a_{ij}$=score given for each pair-wise comparison according to the nine-point scale.

The consistency ratio was calculated and checked for the consistency of the priorities given by respondents, ensuring its values to be less than 0.1 indicating that the data were appropriate to be further analyzed. The criteria weights given on each climatic factor by individuals belonging to three expert categories as Estate managers, Executives and Academia were obtained from the AHP and ranked according to their priority using geometric mean (Table 2).

**Table 1. Saaty's scale used for generation of pairwise comparison matrix**

| Intensity of Importance | Definition |
|---|---|
| 1 | Equal Importance |
| 3 | Moderate Importance |
| 5 | Strong Importance |
| 7 | Very Strong Importance |
| 9 | Extreme Importance |

***Statistical Analysis***

Criteria weights obtained from AHP analysis were analyzed by a Multivariate regression using Statistical software STATA (Version 16.0).

The regression equation for the model was,

$$y_{ik} = \sum_{j=1}^{3} \beta_{jk} c_{ij} + e_{ik} \text{ ................................. (2)}$$

Whereas;

$y_{ik}$- $k^{th}$ response for the $i^{th}$ observation, where k=1,2....10. $y_{ik}$ is the weight given for each of the 10 climate and soil variables by the respondents

$c_{ij}$- $j^{th}$ predictor for the $i^{th}$ observation, where c denotes a dummy variable representing each of the three categories of respondents

$\beta_{jk}$- Coefficient to be estimated

$e_{ij}$- $k^{th}$ equation error for $i^{th}$ observation

## RESULTS AND DISCUSSION

***Results of the AHP***

According to table 2, "Rainfall" was the most important climatic factor based on all three categories while temperature was prioritized by practitioners (executives and estate managers) next to the rainfall. Academics have prioritized soil pH in the second place. The lowest rank was given to wind by practitioners while relative humidity was the least ranked by academics.

**Table 2. Prioritization given by three groups to the 10 climate factors**

| Climatic factor | C1 | C2 | C3 |
|---|---|---|---|
| Soil type | 7 | 3 | 6 |
| Soil pH | 2 | 8 | 7 |
| Soil depth | 4 | 6 | 5 |
| Gravel content | 6 | 9 | 9 |
| Rockiness | 8 | 7 | 8 |
| Sunshine duration and Solar Radiation | 3 | 4 | 4 |
| Wind | 9 | 10 | 10 |
| Rainfall | 1 | 1 | 1 |
| Temperature | 5 | 2 | 2 |
| Relative Humidity | 10 | 5 | 3 |

***Results of the Multivariate Analysis***

Each of the ten models were statistically significant since all the p values were less than 0.05. According to the results of Table 3, the ranks given by three distinct categories (Academics, Executives and Estate Managers) on prioritizing the ten climatic factors were statistically significant, indicating a difference between the perceptions on the impact of the selected climatic factors. The coefficient was analyzed to compare the priority given on the impact of climatic factors by three experts' categories. When "soil type" is considered, highest priority (0.100) has been given by the executives and estate managers have given the least priority (0.081). "Soil pH" and "Soil depth" have been highly prioritized by academics (0.158 & 0.101 respectively) while least prioritized by estate managers with coefficients of 0.077 & 0.076, respectively. The executives have given much equal priority to the above two factors with coefficients of 0.083 each. When compared to the weights of importance given, academics have given much importance for the above two factors than practitioners. Academics have further prioritized "Gravel content" and "Sunshine duration" with highest coefficient 0.085 & 0.118 respectively over the practitioners. In contrast to "Gravel content" the gap between the coefficients given by academics and practitioners to "Sunshine duration and Solar Radiation" was high. When "Wind" and "Rockiness" were considered all the three categories were given an approximately equal importance with coefficient values fluctuating between 0.056-0.059 in "wind" and 0.061-0.067 in "Rockiness". Estate managers have ranked "Rainfall" as the highest priority with a coefficient of 0.212 while academics have scored 0.182 and executives have scored 0.170. Similarly, "Temperature" and "Relative Humidity" have also been prioritized by estate managers with coefficients of 0.177 and 0.096 respectively while academics have ranked with least priority.

**Table 3. Coefficients, Standard errors, and p value for each of the categories grouped by climatic factors**

| Climatic factors grouped by category | Coeff. | Std. Err. | P value |
|---|---|---|---|
| Soil type | | | |
| C1 | 0.090 | 0.018 | 0.0000 |
| C2 | 0.100 | 0.014 | 0.0000 |
| C3 | 0.081 | 0.009 | 0.0000 |
| $R^2$=0.81 P=<0.000 | | | |
| Soil pH | | | |
| C1 | 0.158 | 0.022 | 0.0000 |
| C2 | 0.083 | 0.017 | 0.0000 |
| C3 | 0.077 | 0.011 | 0.0000 |

| | | | |
|---|---|---|---|
| $R^2$=0.761 P=<0.000 | | | |
| Soil depth | | | |
| C1 | 0.101 | 0.013 | 0.0000 |
| C2 | 0.083 | 0.010 | 0.0000 |
| C3 | 0.076 | 0.006 | 0.0000 |
| $R^2$=0.878 P=<0.000 | | | |
| Gravel content | | | |
| C1 | 0.085 | 0.014 | 0.0000 |
| C2 | 0.066 | 0.011 | 0.0000 |
| C3 | 0.069 | 0.007 | 0.0000 |
| $R^2$=0.815 P=<0.000 | | | |
| Rockiness | | | |
| C1 | 0.061 | 0.010 | 0.0000 |
| C2 | 0.067 | 0.008 | 0.0000 |
| C3 | 0.065 | 0.005 | 0.0000 |
| $R^2$=0.885 P=<0.000 | | | |
| Sunshine duration and Solar Radiation | | | |
| C1 | 0.118 | 0.015 | 0.0000 |
| C2 | 0.074 | 0.012 | 0.0000 |
| C3 | 0.089 | 0.007 | 0.0000 |
| $R^2$=0.864 P=<0.000 | | | |
| Wind | | | |
| C1 | 0.057 | 0.013 | 0.0000 |
| C2 | 0.056 | 0.010 | 0.0000 |
| C3 | 0.059 | 0.006 | 0.0000 |
| $R^2$=0.785 P=<0.000 | | | |
| Rainfall | | | |
| C1 | 0.182 | 0.025 | 0.0000 |
| C2 | 0.170 | 0.020 | 0.0000 |
| C3 | 0.212 | 0.012 | 0.0000 |
| $R^2$=0.916 P=<0.000 | | | |
| Temperature | | | |
| C1 | 0.105 | 0.023 | 0.0000 |
| C2 | 0.121 | 0.018 | 0.0000 |
| C3 | 0.177 | 0.011 | 0.0000 |
| $R^2$=0.893 P=<0.000 | | | |
| Relative Humidity | | | |
| C1 | 0.044 | 0.015 | 0.0050 |
| C2 | 0.089 | 0.011 | 0.0000 |
| C3 | 0.096 | 0.007 | 0.0000 |
| $R^2$=0.866 P=<0.000 | | | |

As per the responses for the open-ended questions in the questionnaire, the experts in all three categories had pointed out lack of replanting and poor soil management practices, scarcity of resistance cultivars for drought, impact of the unexpected climatic change as issues in tea productivity. All three groups of experts expressed, practicing good agronomical practices including shade management and cover cropping, irrigation, manuring, soil moisture conservation and developing cultivars which are tolerant to adverse climatic conditions as proper mitigation strategies. The promotion of climate smart tea production while adopting modern technologies has been proposed by the executives. When asking the Experts' perception on government intervention, all the experts suggested to encourage research and development activities and practical implementation while increasing the awareness on climate change and its impact, for the sustainability of the tea sector by mitigating the effect of the climate.

## CONCLUSIONS/RECOMMENDATIONS

Research findings revealed that all three expert groups have given a higher degree of importance to rainfall and temperature by allocating the highest coefficient values. The pairwise comparison of factors revealed that academics have comparatively prioritized soil pH, soil depth, gravel content and sunshine duration and solar radiation higher than executives and estate managers. When the rockiness and soil type were considered, executives ranked these two factors with a higher degree of importance than others. Estate managers have ranked rainfall, temperature, relative humidity, and wind with a higher degree of importance compared to the other two groups. To sustain the tea sector, introduction of climate-smart tea production to manage the negative impacts of climate change, developing cultivars which are tolerant to adverse climatic conditions and adopting good agricultural practices can be mentioned as proper mitigation strategies. It is recommended to develop a corporate strategy based on a common agreement among three expert groups to sustainably mitigate the impacts of climatic change on the tea sector by providing useful insights to these policymakers.

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