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The Impacts of Seasonal Drought on Sri Lankan Tea Cultivation and Mitigation Measures

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ABSTRACT

Drought is a serious ecological hazard and tea is no exception to the frequent damage caused by recent drought on cultivated crops. Tea (*Camellia Sinensis*) is one of the most economic crops and being perennial, tea plant often experiences natural seasonal drought, which affects its growth and productivity. Drought is the single main constraint in any given year on tea yields. Drought affects both the quantity and quality of tea, leading to a considerable loss of export earnings. Production costs can also increase during drought due to the need for additional inputs. The growth stage of tea varies depending on whether it is young tea or mature tea. Measures to reduce the drought impact should be taken according to the growth stage of the Tea. Therefore, the study aims to identify the impacts of seasonal drought on tea cultivation in Sri Lanka and to propose measures to reduce the impact of seasonal drought on Sri Lankan tea cultivation. This study has been undertaken using qualitative research methods. This research was conducted using primary and secondary data to achieve the objectives of the study, which is Key information interviews (KII), Focused Group Discussions (FGD), field surveys and secondary data from Tea Research Institute (TRI). Tea growth during the monsoon season was up to 50% higher than during the spring drought. It was noted from the discussion that temperature, rainfall, air saturation deficits, soil water content, radiation, daylight hours and evaporation are affecting tea production. Further, the temperature, rainfall and the occurrence of extreme weather events all have negative consequences on the tea industry.

Keywords: Tea cultivation, Seasonal drought, Impact, Mitigation practice, Sri Lanka

1. INTRODUCTION

Sri Lanka's tea industry is the country's largest net foreign exchange earner and the primary source of income for the bulk of workers. Tea yield is heavily influenced by weather, particularly droughts, which result in irreversible losses because tea farms rarely use water. Drought is a severe ecological concern, and recent droughts have wreaked havoc on cultivated crops, including tea. One of the most profitable crops is tea (Camellia Sinensis). Tea plants are perennial, thus they are prone to external droughts, which affect their production and productivity (Upadhyaya et al., 2012). Drought is the single most significant constraint on tea yields in any given year. It is a result of a variety of external factors, the most notable of which is seasonal rainfall. Microclimates influence the frequency, severity, and impact of the event. Young plants are more affected than adult plants. Drought increases the quality

of some teas in the short term by enhancing odours and adding a fuller flavour, but it also reduces production (Keen, 2021). A major tea producing area of Sri Lanka during an extreme drought through the onset of the North-east Monsoon to capture effects of extreme climate events that are likely to become more frequent with climate change. Tea growth during the monsoon season was up to 50% higher than during the spring drought. Heavy rains, on the other hand, erode topsoil and wash fertilizers and other chemicals away. It was also suggested that the length of the dry and wet seasons per year in the primary plantation region may be increased by 10%. As a result, both drought damages and soil losses in tea-growing areas will increase in the future.

Tea demands an environment that is moderately hot and humid. Climate has an impact on agricultural productivity, distribution, and quality. As a result, the adaptability of the climate is the first factor to consider before cultivating tea in a new location. The rate of photosynthesis, as well as growth and dormancy, are all influenced by temperature. The temperature range between 13^0 C and 28-32 ^{0}C is ideal for tea growing in general. Temperatures exceeding 32°C are adverse for optimal photosynthesis, especially when combined with low humidity. Much extreme weather and climate events have been recorded as temperatures have risen since roughly 1950, and projected increases in long-term droughts and precipitation extremes in Africa, East Asia, South Asia, and Southeast Asia, the world's key tea-producing regions, are quite likely. During the years 2011-2015, the metrological organization not only documented the warmest year, but also discovered a huge number of extreme weather and climate phenomena, such as heat and cold waves, tropical cyclones, flooding, droughts, and severe storms (WMO, 2016).

In Sri Lanka, temperatures have increased markedly over the last one and a half centuries and a warming rate have accelerated in recent years. For example, between 1961 and 1990, the mean temperature climbed at a pace of 0.0160°C per year, and between 1987 and 1996, it increased at a rate of 0.0250°C per year. In terms of future climate, the global surface temperature rise is expected to exceed 1.50 degrees Celsius by the end of the twenty-first century, and warming will continue beyond 2100. Relatively low temperatures are advantageous to nitrogen metabolism, particularly amino acid biosynthesis. High temperatures have a beneficial effect on carbon metabolism and polyphenol biosynthesis. Although it is positively connected with polyphenols, the average temperature 15 days before tea plucking shows a substantial negative correlation with amino acids (Qiusl et al., 2014). Water supply and temperature determine the relative humidity of a tea-growing site. The number of hours of sunlight is proportional to the intensity of solar radiation and has an impact on temperature (Han et al., 2007).

Nuwara Eliya, Kandy, Badula, Ratnapura, Kegala, Mathala, Galle, Matara, Kurunagal, Monaragala, Colombo, Kaluthura, and Hambanthota are among Sri Lanka's 13 district tea growing districts. The majority of Sri Lanka's tea-growing regions receive monsoon rains from the southwest and northeast. Tea gardens, on the other hand, are badly impacted by water scarcity due to a lack of precipitation throughout the year. The major growth season is from early January to late March in most growing areas. However, the major season in some portions of the Uva and Central zones is from late June to early September.

The impact of a hotter and wetter environment on Sri Lanka's tea production is adverse. Increased rainfall and increased average temperature have a negative proportional impact in high, medium, and low emissions futures, according to our predictions. Temperature, rainfall, air saturation deficits, soil water, radiation, daylight hours, and evaporation all affect tea production. Temperature,

rainfall, and the occurrence of extreme weather events all have negative consequences for the tea industry. Sri Lanka's tea industry produces about 388 million kg of tea each year and earns 1.6 billion dollars in foreign exchange. However, according to a report published by the Sri Lanka Export Development Board, there has been a steady reduction for the past four years. Drought, dry spells, and below-average rainfall are the main causes (Paul, 2016). Drought is significant abiotic stress that impacts plant physiology and, as a result, crop output. Drought mitigation options become critical in this situation to protect Sri Lanka's tea economy.

During these dry months, new and mature tea might be severely harmed. Planting in young sprouts tea causes significant damage in the first and second years. To minimize such vulnerabilities and promote timely recovery, the following precautionary measures should be taken both before and during the drought. The growth stage of tea varies depending on whether it is young tea or mature tea. Measures to reduce the drought impact should be taken according to the growth stage of the Tea. Therefore, the study proposed a mitigation practice to reduce the impact of seasonal drought on Sri Lankan tea cultivation and to take some measures to protect tea crops from the effects of drought.

2. METHODOLOGY

The study is to be conducted by qualitative research methods. The research was conducted using primary and secondary data collection techniques to achieve the objectives of the study. The primary data collection was done by Key Informal interview (KII), Focused Group Discussion (FGD), and field survey.

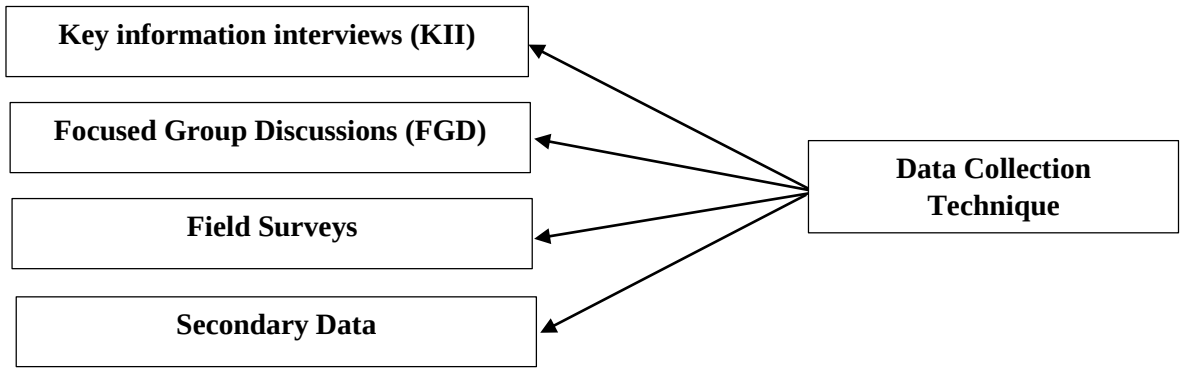

Figure 1: Data collection

Key information interviews (KII): Considering KIIs are semi-structured and conversational, semi-structured questionnaire schedules were created. The current drought condition and measures to mitigate the effect were the focus of KIIs. A key information interview was done with a director from the Tea Research Institute (TRI), two technical heads (moisture, chemical), and a soiled head from TRI, one TRI librarian, four TRI employees, two estate managers, and fifteen estate workers.

Focused Group Discussions (FGD): FGDs are a type of group discussion that can be used to collect a wide range of information from a group of people. These data are primarily qualitative. These open and easygoing dialogues with a protocol can yield a wealth of information for a study by generating experiences, viewpoints, and ideas. The goal in determining the size of a focus group for an FGD was to obtain as many different ideas and opinions as feasible. The participants in this study were divided into groups of 5 to 9 people, who were chosen based on their familiarity with the issue. Discussions were

conducted with the Tea Research Institute director, technical head, chemical fertilizers head, laboratories staffs, and production head.

Field surveys: The researchers find out the major problem of the impact of seasonal drought on tea cultivation and its production level from the field survey.

Secondary data: Secondary data were collected from reports and circulars collected from TRI, Research articles, TRI annual reports, records, books, magazines, and newspapers. The result of this study was obtained through such methods.

Data Analysis: This study relied heavily on qualitative data acquired through focus groups, interviews, and questionnaires, as well as secondary data. To accomplish the overall aims, TRI provided complementary secondary data. Based on primary and secondary data collecting, the entire study used a mixed-method approach. Through qualitative and pertinent secondary data, data triangulation was used. The primary tea cultivation areas in Sri Lanka were combined to conduct qualitative analysis.

3. RESULTS & DISCUSSIONS

3.1 Climate Change and Seasonal drought impact on Sri Lankan tea cultivation

The climatic and agro-ecological framework within which the potential tea growing locations are situated is defined by Sri Lanka's geographic position and terrain. Practically the entire wet zone, as well as a significant amount of the intermediate zone, especially in the Uva basin and eastern Badulla region, is suitable for tea cultivation. According to the elevation grown at, tea fields and all tea sold in Sri Lanka are divided into three groups: High grown or Up Country (Elevation >1200m), Medium grown or Mid Country (Elevation 600-1200m), Low grown or Low Country (Elevation 0-600m).

Ruhuna and Sambaragamuwa are located in the low-growing zone, Kandy is located in the mid-growing region, and Nuwara Eliya, Dimbula, Uva, and Uda Pussallawa are located in the high-growing region of Sri Lanka. Non-tea growing areas range in elevation from sea level to roughly 2340 meters above sea level. These places have various topographic characteristics, such as flat-low-land along the coast and through-high-land regions in the country's central region (Jayasighe *et al.,* 2020).

Furthermore, tea production has been categorised by agro-climatic districts as well as administrative districts. There were, however, well-defined boundaries. When it came to the geographical distribution of tea production, the Nuwara - Eliya district had the largest production of high-grown tea at 75.2 percent (49 mn kg). The rest came from the districts of Badulla (22.75 percent), Kegalle, and Kandy. The largest tea production was reported from Nannoya/ Lindula/ Thalawakelle, which totalled over 8.1 million kilograms (12.5 percent).

The tea production picture offered by the medium and low elevations is completely different from the tea production picture provided by the high elevations. It similarly extended across multiple districts and was not restricted to a particular district. In terms of medium-grown tea, Kandy provided 21.9 million kg (46.43 percent), Badulla 11.6 million kg (24.51 percent), and Nuwara-Eliya 10.2 million kg (21.6 percent). The others came from the districts of Ratnapura, Matale, Kegalle, and Matara (7.5 percent). The agro-climatic districts Gampola/ Nawalapitiya/ Dolosbage lead the medium elevation tea production. This amounted to roughly 12.4 million kilograms or 26.34 percent of the total medium-grown crop. The majority of low elevation tea production comes from the Ratnapura administrative area, which produced more than 66 million kg (34.4 percent) in 2018. The agro-climatic district of Ratnapura

produced over 52.4 million kilograms, followed by the agro-climatic district of Galle, which produced over 43.9 million kilograms (22.9 percent). The largest tea production was recorded by Ratnapura agro-climatic district, which belongs to the low elevation zone in Sri Lanka, in terms of agro-climatic districts of high, medium, and low elevations (Jayasighe *et al.,* 2020).

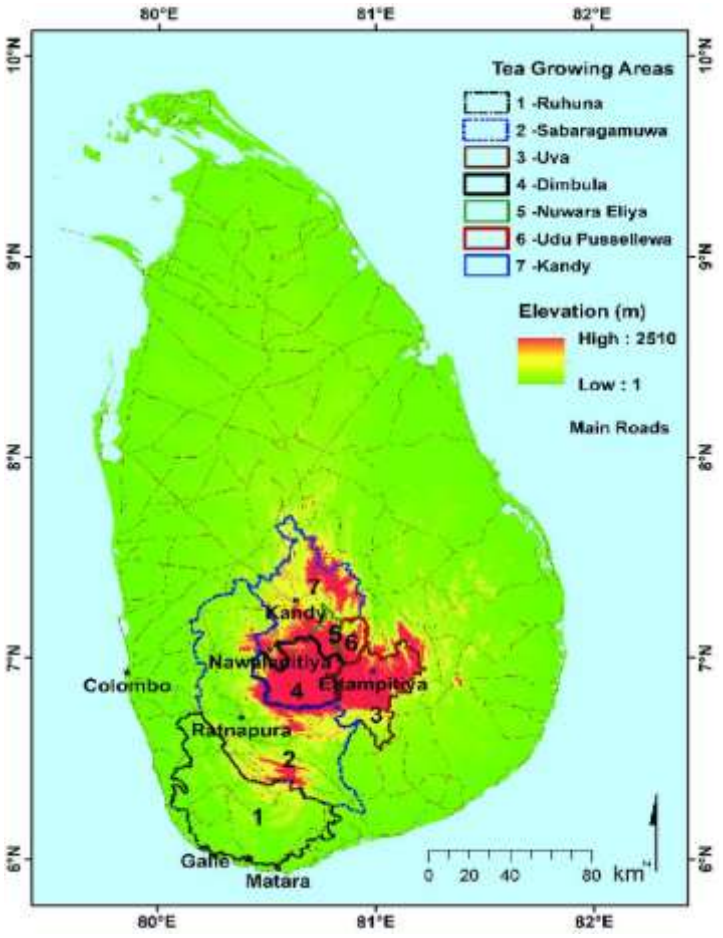

Figure 2: Major tea growing areas in Sri Lanka (Jayasighe et al., 2020)

The weather change has grown more erratic, causing uncertainty in agricultural production, including tea production (FAO, 2015). Temperature, rainfall, and the occurrence of extreme weather events like drought have all harmed tea yield and production in recent decades (De costa et al., 2007; 2008; 2015). Droughts in the region are mostly triggered by a weak southwest monsoon on the Indian subcontinent, which results in a lack of rain during the rainy season (FAO, 2015). Nuwara Eliya, Kandy, Badula, Ratnapura, Kegala, Mathala, Galle, Matara, Kurunagal, Monaragala, Colombo, Kaluthura, and Hambanthota are among Sri Lanka's 13 district tea growing districts. The majority of Sri Lanka's tea-growing regions receive monsoon rains from the southwest and northeast. Tea gardens, on the other hand, are badly impacted by water scarcity due to a lack of precipitation throughout the year. The major growth season is from early January to late March in most growing areas. However, the major season in some portions of the Uva and Central zones is from late June to early September. Therefore, drought affects both the quantity and quality of tea, leading to a considerable loss of export earnings. Production costs can also increase during drought due to the need for additional inputs (Wijieratne *et al.,* 2007).

In Sri Lanka, the intensity of these climate impacts on tea production will likely vary across the major tea growing regions, in low-, up-and mid-country areas Prior re-inputs (Wijeratne et al., 2007) search has also identified eight agro-ecological tea-growing areas which are most vulnerable to climate change (Wijeratne et al., 2013). Drought is the single main constraint in any given year on tea yields. It is a byproduct of many external forces, most especially seasonal rainfall. It's situational, with microclimates affecting frequency, severity and impact. However, tea gardens are severely affected by water scarcity due to a lack of precipitation in all seasons. The main period in the most growing area is from early January – late March. However, in some parts of the Uva and Central zones, the main period is from late June – early September (Wijeratne et al., 1996).

Figure 3: Drought effects on tea crops (Field Survey, 2021)

The pictures shows (figure 3) the tea plants are affected during the drought season. So the drought effects differ with the growth stage of tea that is whether it is young tea (before first pruning) or mature tea (after first pruning). Hence drought mitigation measures also should vary according to the stage of growth of the tea.

3.2 DROUGHT MITIGATION MEASURES

3.2.1 Drought Mitigation Measures for Young Tea

Measures to be adopted before and during drought	Actions to be taken after drought
• Mulching • Weed control • Spraying of Potassium sulfate and kaolin • Irrigation • Skiffing • Fertilizers application • Green manure crops • Pest control	• Fertilizer applications • Bringing into bearing and plucking • Resupplying

Source: Tea Research Institute of Sri Lanka (TRI)

Mulching: Before the rain ends, the inter-rows of fresh clearings should be thatched with Guatemala or Mana grass. Fresh material in the amount of 37.5 metric tons per hectare (15 tons per acre) would be required for this purpose. This might be obtained from a single circling of a well-kept grass clearing of one hectare. Mulching can be done with partially decomposed waste materials like sawdust, paddy husk, and discarded tea (at a rate of 15–20 tons per hectare). They can be put as a 1"-2" thick

coating, leaving about 6"–8" from the tea plants' root. If paddy husk or sawdust are utilized, 2–3 kilograms of urea per 100 kg of material should be combined or sprayed on them. Mulching should be done at least twice a year, depending on the rate at which the material decomposes.

Weed control: During the drought, new clearings should be kept weed-free. As a result, weeding should be finished before the commencement of the drought. Weeds might be chopped to reduce competition for soil moisture if they are present during the drought. Spraying any herbicide during a drought is not recommended because plants are under water stress.

Spraying of Sulphate of Potash (SOP) or Muriate of Potash (MOP) and Kaolin: A knapsack sprayer can be used to spray 2 percent SOP or 2 percent MOP (at a rate of 2 kg/ ha in 100 L of water during the first year, 4 kg/ ha in 200 L of water during the second year, and a kg/ ha in 400 L of water during the third year) to reduce leaf transpiration. Spraying should begin at least a month before the drought begins and continue for 2-4 weeks, depending on the severity of the drought. To improve K absorption, urea can be combined (2 kg/ha) with MOP SOP. Spraying should be done shortly after flush harvesting in plucking fields to guarantee proper spray droplet deposition on mature leaves. Drenching foliage is not recommended since the drip will cause leaf burn. Kaolin is sprayed (5-10 of Kaolin in 100 L of water). Transpiration of heat and water is reduced by one of the leaves of immature tea plants. Drought should be sprayed as soon as possible.

Irrigation: If water is available, irrigate first-year plants every four to seven days with 400 to 500 millilitres per plant/application. For second-year plants, the volume should be doubled and irrigated at 7-10 day intervals. Young tea in their second to the fourth year from planting can be partially defoliated by giving a light skiff to remove the top 2" – 3" of foliage if the dryness is protracted and the plants stay wilting in the morning hours.

Skiffing: If the plants wither in the morning after a lengthy period of dryness, they can be transferred by partially reducing their leaves by 2"-3" on the upper leaves of young tea plants aged two to four years. These types of mitigations should be followed both before and after the drought for young tea plants.

Fertilizer application: During dry weather, fertilizer application should be avoided.

Green manure crops: SLAT hedgerows and other inter-planted green manure crops with tea should be lopped. Crops should be trimmed back to the ground level before a drought begins.

Pest control: Dry-weather pests include mites, tea tortrix, and nettle grubs. Tea plants can be severely harmed by outbreaks of dry season pests (please refer to TRI Advisory Circulars on pest control for their management).

Fertilizer application: Only once the plants have fully recovered from moisture stress, the new leaves of defoliated plants have fully opened and young tea fertilizer is administered.

Bringing into bearing and plucking: Only until the plants have fully recovered from moisture stress and the badly affected plants have entirely defoliated should they be brought into bearing. Plants in the second to the fourth year of plucking should only be picked once they have fully recovered from moisture stress and are flushing again. During the first few months, light plucking (Mother–leaf – plucking) should be used.

Resupplying: Before beginning any usual replanting procedure for the year, it is vital to prioritize resupplying the vacancies. It's critical to identify re-scheduled if drought casualties are discovered in

isolated patches. If the soil is very shallow or gravelly, resupplying can be done in trenches (30cm wide and 45cm deep) filled with compost and left to settle for a while.

These types of mitigations should be considered for young tea plants after the drought season has passed.

3.2.2. Drought Mitigation Practice for Mature tea

Actions to be taken before the drought	Actions to be taken after drought
• Tea plucking • Spraying of Potassium sulfate and kaolin • Skiffing • Pruning • Forking • weeding • Green manure plants grasses • Pest control	• Fertilizer application • Plucking • Pruning • Resupplying vacancies • Other considerations

Source: Tea Research Institute of Sri Lanka (TRI)

Plucking: Theta bushes in any particular field are vulnerable to varying degrees of drought damage. Light plucking (Mother – leaf – plucking) should be used until flushing returns to its regular schedule.

Spraying of Sulphate of Potash (SOP) or Muriate of Potash (MOP) and Kaolin: A knapsack sprayer can be used to spray 2 per cent SOP or 2 per cent MOP (at a rate of 2 kg/ ha in 100 L of water during the first year, 4 kg/ ha in 200 L of water during the second year, and a kg/ ha in 400 L of water during the third year) to reduce leaf transpiration. Spraying should begin at least a month before the drought begins and continue for 2-4 weeks, depending on the severity of the drought. To improve K absorption, urea can be combined (2 kg/ha) with MOP SOP. Spraying should be done shortly after flush harvesting in plucking fields to guarantee proper spray droplet deposition on mature leaves. Drenching foliage is not recommended since the drip will cause leaf burn.

Skiffing: Young tea in their second to the fourth year from planting can be partially defoliated by giving a light skiff to remove the top 2" – 3" of foliage if the dryness is protracted and the plants stay wilting in the morning hours (At the bottom of the kolunthu mudichchu).

Pruning: Pruning should generally be done just before or during a drought. Pruning during dry conditions might cause considerable shrub debilitation.

Forking: This practice should be avoided during or shortly before a drought since it will exacerbate soil moisture loss.

Weeding: During a drought, fields should be kept weed-free. As a result, weeding should be finished before the commencement of the drought. If weeds appear during a drought, they can be chopped to reduce competition for soil moisture with the tea. Herbicides should not be sprayed during dry weather.

Green manure crops: All SALT hedgerows and other inter-planted green manure crops with tea should be lopped. Crops should be trimmed back to the ground level before a drought begins.

Pest control: Dry-weather pests include mites, tea tortrix, and nettle grubs. Tea plants can be severely harmed by outbreaks of dry season pests (please refer to TRI Advisory Circulars on pest control for their management).

Fertilizer application: Drought-affected mature tea bushes should only be fertilized once they have fully recovered from moisture stress, i.e. when the bushes begin flushing. It's also critical to wait until defoliated bushes have entirely defoliated and the initial set of new leaves has fully expended before fertilizing them.

Plucking: Tea bushes in any given field are exposed to varying degrees of drought damage. Light plucking (Mother – leaf – plucking) should be used until flushing returns to its regular schedule.

Pruning: Drought-stricken fields should not be pruned until the shrubs have fully recovered and produced enough foliage. Drought-affected fields should also be rested until sufficient root reserves have been accumulated.

Resupplying vacancies: After the new clearing space has been infilled, the best of the leftover nursery plants should be used to fill in gaps in mature tea fields. Vacancies in planting tea should be filled with appropriate soil reconditioning grass after two years.

Other considerations: To avoid fire threats during a drought, all grass clearings must be looped. During dry times, however, shade trees should not be lopped.

4. CONCLUSIONS

Drought has gradual inception than other natural disasters, but it has a significant influence on agriculture, the economy, water resources, the environment, ecosystems, and society. Drought has also impacted the tea industry, as the tea plant has been destroyed as a result of the drought. In Silence, it's also impacting the tea economy's growth rate. Climate change is a major issue in the current scenario all over the world, so a comprehensive long-term and short-term drought management strategy are needed to mitigate the devastating consequences of drought while also assisting tea plants in developing drought readiness plans. Tea plantations are particularly vulnerable to climate change's detrimental consequences. Because the effects of climate change will become increasingly severe in the future, good agricultural practices and timely measures will be required to meet these new difficulties.

As a result, new tea plantations should be established only on the most suitable sites, using adequate adaptation procedures, as well as the right establishment and management of shade trees in tea plantations. Climate change's effects will become increasingly severe in the future. To counter these increasing issues, it is vital to adopt sound agricultural practices and take early precautions. Thus, the tea plants harmed by the drought era were proposed in this study, and if the measures were followed, the tea plants would suddenly develop well. It will contribute to the economic development of our country.

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