Research on Climate Change & Development of Carbon budget for Tea Plantations

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Introduction and Focus

Sri Lanka has become the second in the Climate Risk Index 2018

Greenhouse gas → Global warming

- Concentrations of CO_2 : The highest peak in 61 years recorded in May 2019
- Temperature
- Rainfall pattern

•Climate Change (CC) influences many sectors of the Sri Lankan economy including plantation agriculture

•→ **Extreme weather events**.

- •Heavy Rainfall
- •Severe drought

Take place when least expected

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2nd Place in Global Climate Risk Index

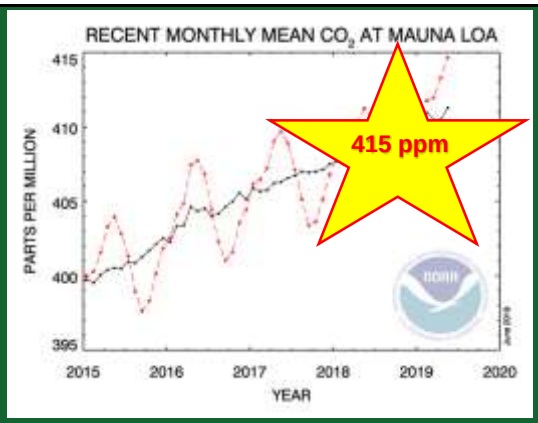
Calculated annually

Based on the most reliable data sets

Direct impacts of extreme weather related events:
- storms
- floods
- heat waves etc

&

associated socio-economic data



Global atmospheric carbon dioxide concentrations spike every April or May
In 2019 the spike was bigger than usual.
Dashed red = monthly mean values;
Black line shows the same data after the seasonal effects have been averaged out.

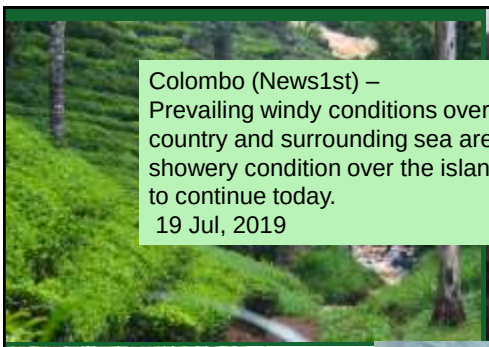
Credit: NOAA.

Period	Average increase of CO_2 per year
Early 1980s	0.6 ± 0.1 ppm
Last 10 years	2.3 ± 0.6 ppm
2015 - 2016	3.5 ± 0.1 ppm

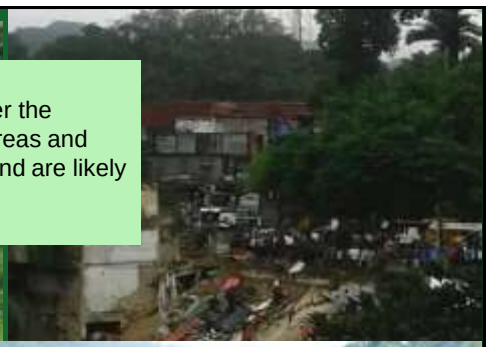
Sri Lanka recorded the hottest weather in April 2019
Apr 12, 2019 ColomboPage News Desk, Sri Lanka.

COLOMBO (News 1st): Severe drought in some areas; livestock deaths reported
02 Jun, 2019

COLOMBO (News 1st):
The water bodies located around the hydro-power plants recorded the lowest water level in 29 years.
13 Jul, 2019



Colombo (News1st) –
Prevailing windy conditions over the country and surrounding sea areas and showery condition over the island are likely to continue today.
19 Jul, 2019



Daily news
Landslides in Ginigathhena
19 July 2019

- Being a rain-fed plantation crop, grown in different elevations & terrains, tea is highly vulnerable to CC.
- Impacts of CC vary in different tea growing regions.
- Soil quality/fertility can be further deteriorated under CC due to increased soil erosion and burning of soil carbon etc.

→ Other environmental problems eg. Eutrophication

- CC affects on the quality of tea in different tea growing regions.
- Levels of pest and disease infestations may vary in different regions & new pests/diseases out-breaks are possible under CC.

Sri Lankan tea industry is at a risk

Review on Climate Change Research

Effects of Rainfall on tea yield

Agro Ecological Region	Optimum Rainfall (mm/month)	Loss of tea yield (kg/ha/month/100 mm RF deficit)
WL	350±20	29±3
WM	417±49	36±6
WU	223±38	55±7
IM	227±10	81±11
IU	303±34	39±3

± *Standard Error of mean*

(Wijeratne et al., 2007)

Optimum rainfall vary from 223-417 mm/month

The drought impacts are in the range of 29-81 kg/ha/month/100mm RF deficit

Predictions related to tea plantations

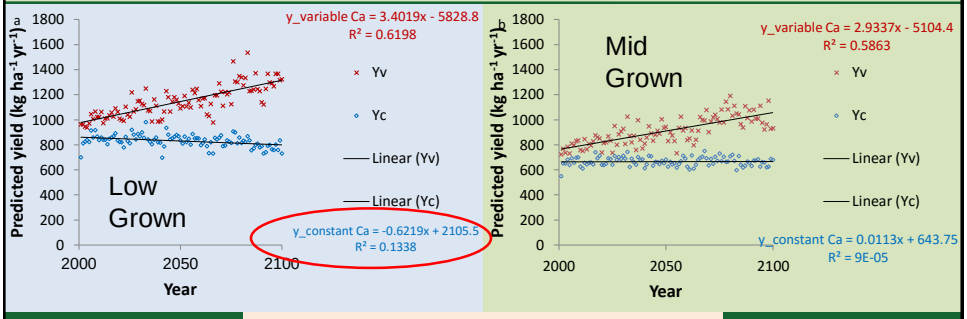
Baseline & GCMs	*Yield Projections for the year 2050*		
	Ratnapura*(WL)* *Low Grown*	Kandy*(WM)* *Mid Grown*	N'Eliya*(WU)* *High Grown*
Baseline	***2489***	***2217***	***2454***
HadCM3-A1F1	2348	2174	3130
HadCM-B1	2419	2189	3115
CGCM-A1F1	2314	2217	3108
CGCM-B1	2380	2228	3072
CSIRO-A1F1	2401	2246	3167
CSIRO-B1	2472	2245	3137

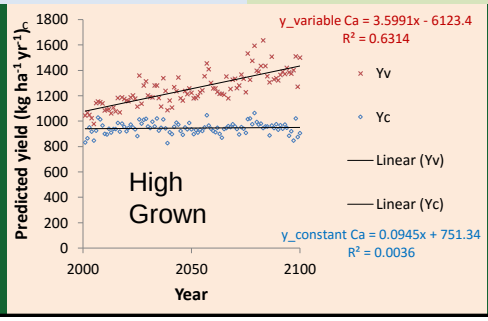
(Wijeratne et al., 2007)

CC - Multifactorial phenomenon
Model predictions of the SDGVM according to A1F1 scenario:

(Wijeratne et al., 2011)

Impacts of climate change on the long-term tea yields during the 21st century





(Wijeratne et al., 2011)

How to over come the challenges of CC

Good Agricultural Practices

introduced by the TRI for improving soil and micro-climate in tea plantations to minimize adverse impacts & sustain productivity of tea lands

Adaptation Measures

Mitigation Measures

Adaptation Measures

1. Proper land selection and utilization

2. Proper cultivar selection
   - Drought/Heat/Flood/Pest/Disease tolerant cultivars
   - Poly- or bi- clonal seedling tea for drought prone areas
   - Graft combinations

3. Management Options

   a) Drought management package
   (Anandacoomaraswamy, 1997)

   b) Experiments are in progress to increase the climate resilience of tea cultivars

c) Improvement of Arial Environment

Proper establishment and management of shade trees

d) Irrigation

e) Mulching/cover crops

Use of artificial mulch for soil moisture retention (*Bandara et al., 2016*)

f) Rain water harvesting

4. Improvement of soil

- Increasing soil organic matter content
- Soil & moisture conservation
- Site specific fertilizer recommendation
- Slow release fertilizer
- Biofilm biofertilizer for nursery: 50 % reduction of fertilizer usage (De Silva et al., 2014)
- Beneficial microbial inoculants: reduce the use of fertilizer by one-third (Tennakoon et al., 2016)

CC vulnerability map for tea in Sri Lanka

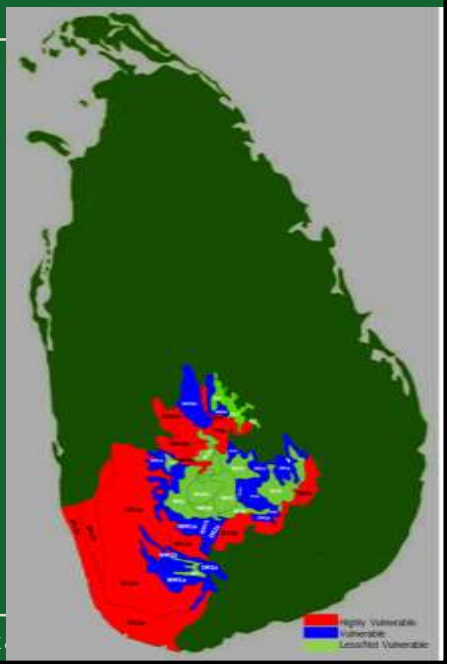
Vulnerability indices were developed using Rainfall, Temperature and soil data

Highly Vulnerable areas:
WL1a, WL1b, WL2a, WM2a, WM2b, WM3a, IM2b, IM3a and IM3c

Vulnerable areas:
WM1a, WM1b, WM3b, IM1a, IM2a, IU3a, IU3d and IU3e.

Proper adaptation and mitigation practices to minimize the possible negative impacts

(Wijeratne and Chandrapala, 2014)



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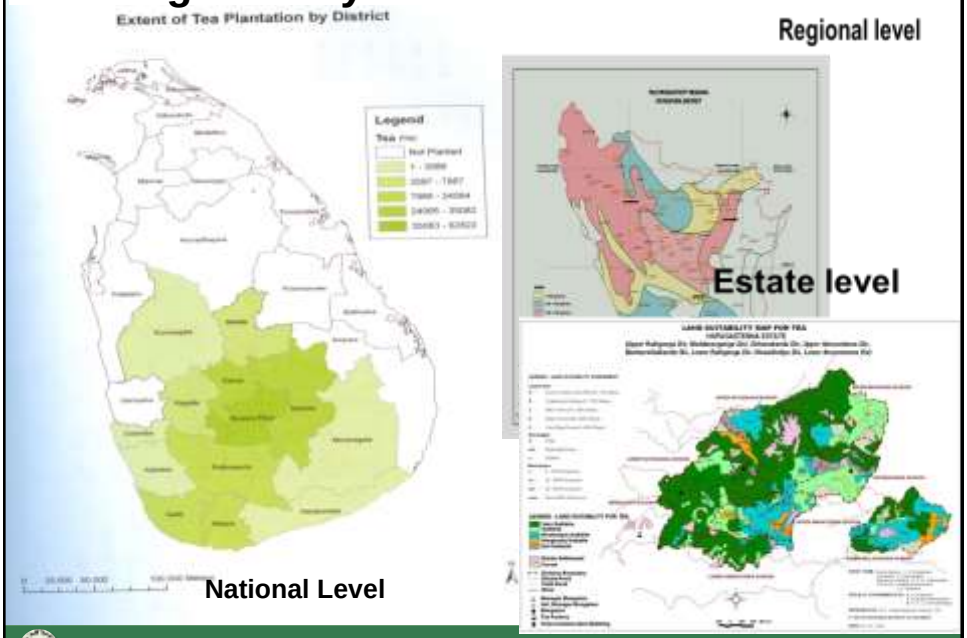
Growing tea only in most suitable lands



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Diversification of marginal lands to other uses

Intercropping

Mixed cropping

Timber plantations

Energy plantations

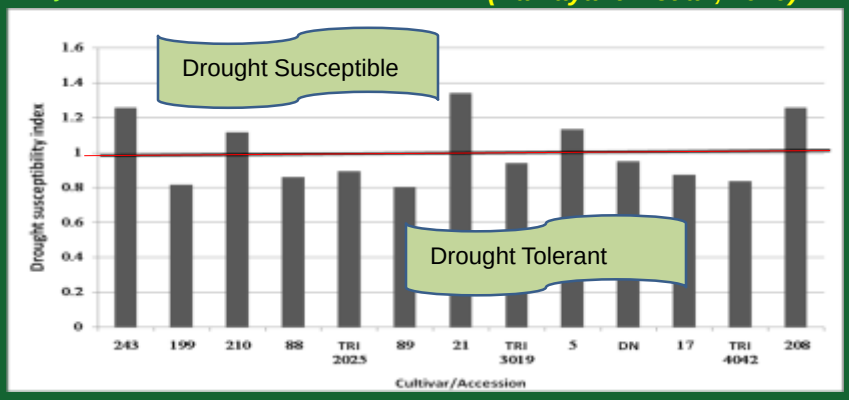
Infilling vacancies

Thatch banks

Drought Susceptibility Index DSI

Using the physiological parameters such as net photosynthesis rate and relative water content with known cultivars DSI was developed and tested successfully

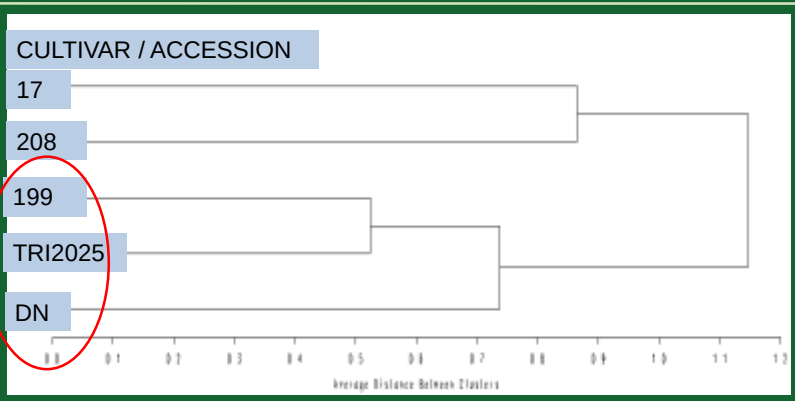
(Damayanthi et al., 2010)



Facilitates early detection of drought susceptible/tolerant cultivars

(Damayanthi et al., 2017)

Use of climate resilient cultivars



Based on C & N stocks and drought tolerance ability accession 199, cultivar TRI2025 and DN can be recommended for future tropical climates such as Uva upon fulfilment of other factors such biotic stress tolerance and better quality etc….

(Wijeratne et al., 2018)

- Development of graft combinations

Successful graft combinations for drought (Cultivar/Cultivar)

TRI 2023 on CY 9
TRI 2026 on DN
TRI 4046 on DN
TRI 4052 on DN

Evaluation of cultivar/seedling combinations (Cultivar/Seedling)

TRI 4053 on Sapumalkanda seedlings

- Development of by- and poly-clonal seedling tea for drought prone areas

- Development of new tea cultivars through controlled hybridization for biotic and abiotic stress tolerance is in progress

(Anon, 2017)

Soil conservation & improvements

Soil conservation

Soil improvement
(Burying of pruning, green manure & compost applications etc)

CC Mitigation: C sequestration & C balance

- Preliminary investigations showed a negative C balance in Sri Lankan tea industry (***De Costa et al., 2008***)

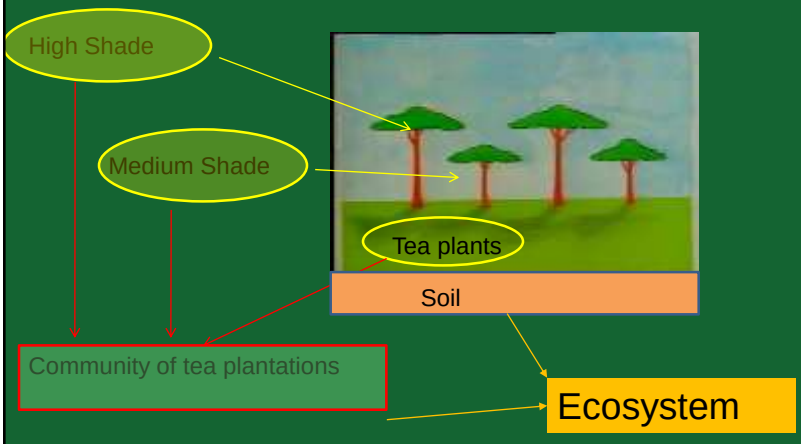
Based on assumptions

Region	C absorption (Mg/yr)	C emission (Mg/yr)	C balance (Mg/yr)
Low Grown	1.426	0.677	- 0.749
Mid Grown	1.278	0.334	- 0.944
High Grown	0.874	0.430	- 0.444

(***De Costa et al., 2015***)

This finding created detailed investigations of CO_2 sequestration & emission studies on tea plantations in Sri Lanka

Tea Plantation Community + Soil = Tea Ecosystem



Detailed investigations on C sequestration potential of tea plantations

C sequestration potential

at community level considering tea, HS and MS biomass C stocks
all three tea growing regions
both seedling and VP tea

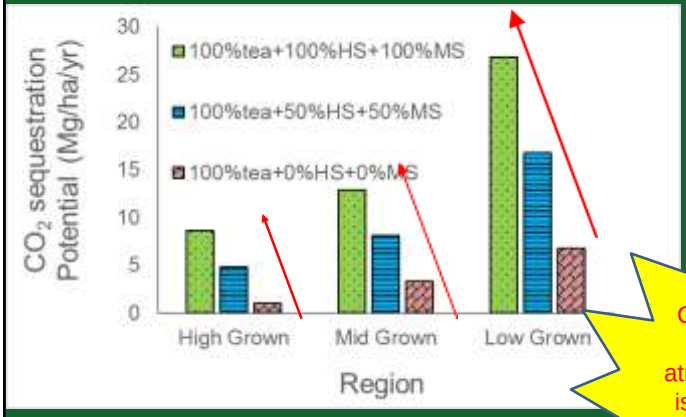
Summary findings of the project

- C Sequestration potential
  - ❖ Seedling tea > VP tea
  - ❖ Substantially increase with
    the compliance of TRI recommendations →
    incorporation of shade trees,
    proper spacing,
    better management etc
  - ❖ Varies in million Mg/yr of CO_2 equivalents as→

High Grown		Mid Grown		Low Grown
0.37	<	1.03	<	2.81

(Wijeratne et al., 2014a)

Carbon sequestration potential of tea plantations



Contribution to reduce atmospheric CO_2 is considerable

Incorporation of shade trees i.e. High Shade (HS) and Medium Shade(MS),
increases the C sequestration potential of the community of tea plantations tremendously

(Wijeratne et al., 2014b)

Detailed investigation on CO_2 emissions

Soil CO_2 emission (soil respiration) was measured using Anderson method (1982).

Data collection over a natural moisture gradient

Data collection in all major tea growing soil series

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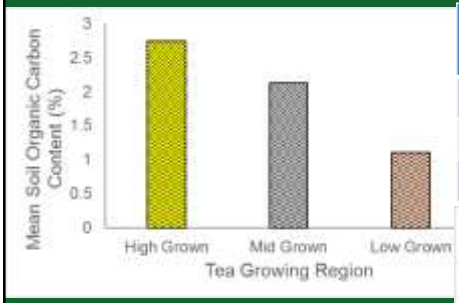
1. High Grown: Maskeliya, Mattakelle & NuwaraEliya
2. Mid Grown: Kandy, Ukuwella
3. Low Grown: Weddagala, Pallegoda & Dodangoda

Soil series selected with the assistance of Head, SPND, TRI

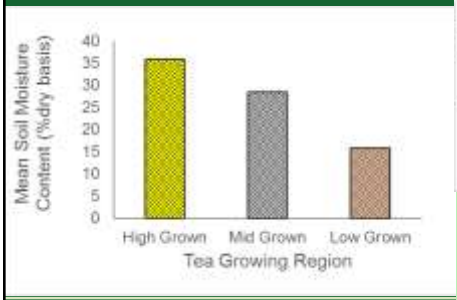
Soil Organic Carbon
Soil Bulk Density
Soil Moisture
Soil Temperature
Soil pH

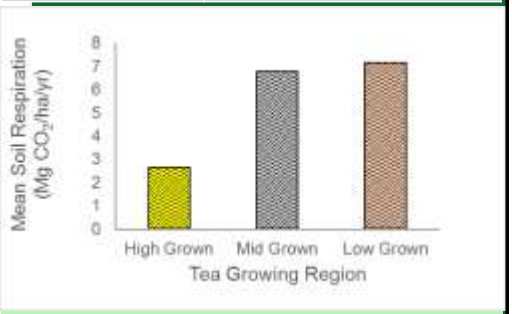
Expected to quantify the soil CO_2 emissions and develop GHG inventory under the **Cropland remaining Cropland** for the category of **Agriculture Forest and Other Land Use (AFOLU) sector**

Summary of early findings



Region	Mean Soil Temperature ^{o}C
High Grown	20.6 ± 0.2
Mid Grown	23.3 ± 0.1
Low Grown	29.2 ± 0.3





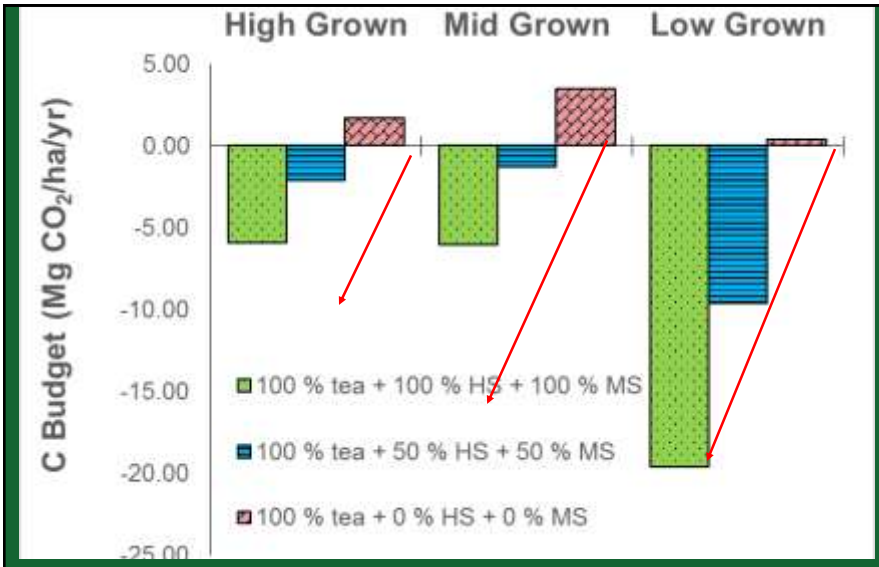
Correlations of Soil Respiration
Vs Soil Moisture content
Vs Soil Organic Carbon Content

Provisional C budget for tea plantations

CO_2 sequestration data were taken from Wijeratne et al., 2014

C budget = CO_2 (emissions – absorption) from tea ecosystem

Tea Growing Region	Soil Series	CO_2 emissions (Mg of CO_2/ha/yr)
High Grown	Mattakelle	2.66
Mid Grown	Kandy	6.79
Low Grown	Pallegoda	7.17



Incorporation of shade trees i.e. High Shade (HS) and Medium Shade(MS) makes the C budget of the tea plantations more and more negative, i.e. tea plantations become more and more climate positive

Summary

Tea plantations are highly vulnerable to the negative effects of climate change

Impacts of climate change will be more and more severe in future

It is necessary to follow good agricultural practices and take timely precautions to overcome these emerging challenges

New tea plantations to be initiated only at best suitable lands following proper adaptation practices

Proper establishment and management of shade trees in tea plantations is a must

Policy makers should be influenced to explore potentials to tackle new markets such as "Payments for Environmental Services" for the sustainability of the tea industry

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  - ✓ Hapugastenne Estate (Maskeliya),
  - ✓ Laxapana Estate,
  - ✓ Craighead Estate,
  - ✓ Elkaduwa Estate,
  - ✓ Talgaswella Estate,
  - ✓ Hapugastenne Estate (Gallalla),
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