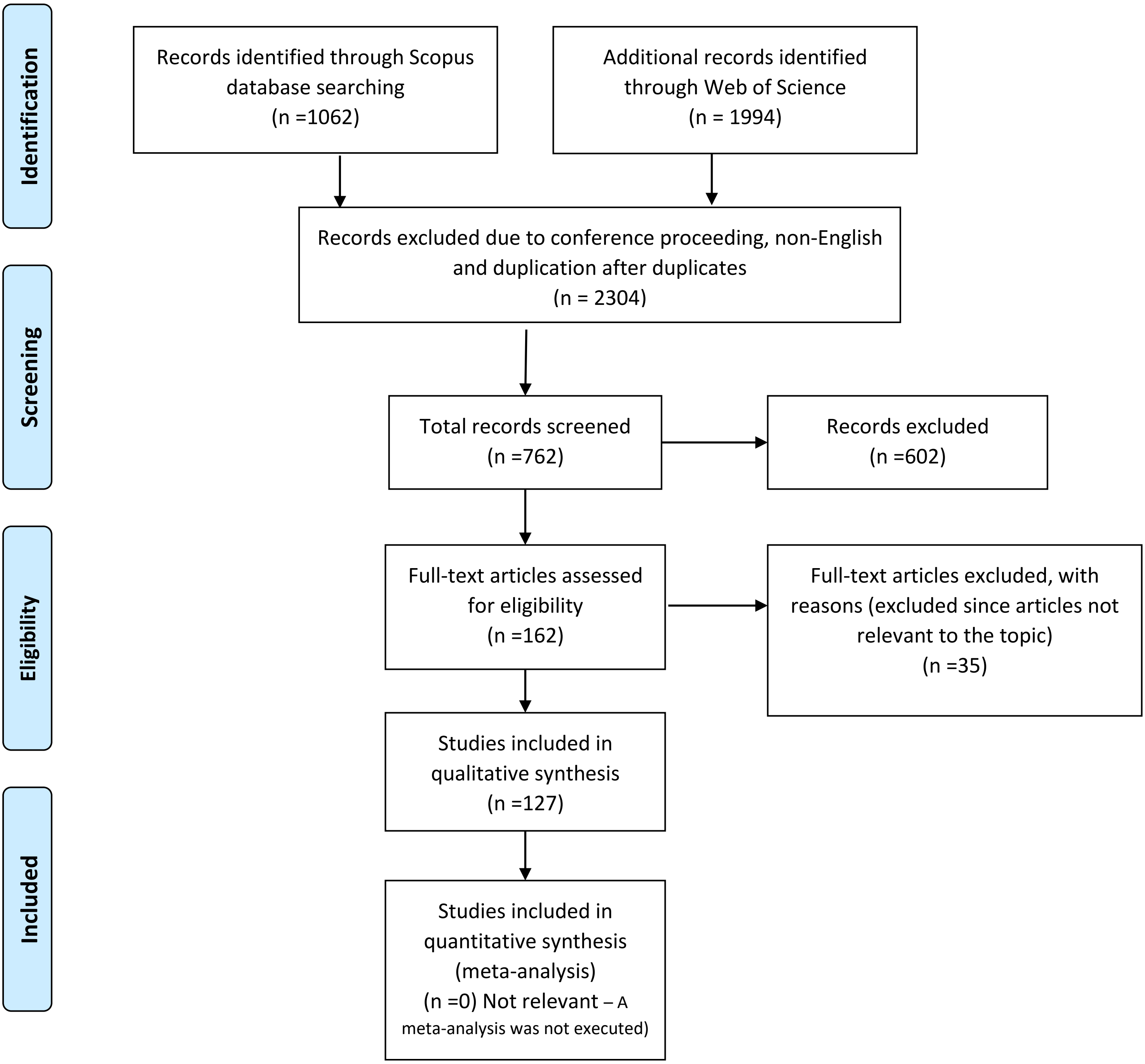
Supplementary Material

Supplementary Figure S1 - PRISMA 2009 Flow Diagram



Note. The PRISMA format is adapted from Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009)[1]. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 (www.prisma-statement.org).

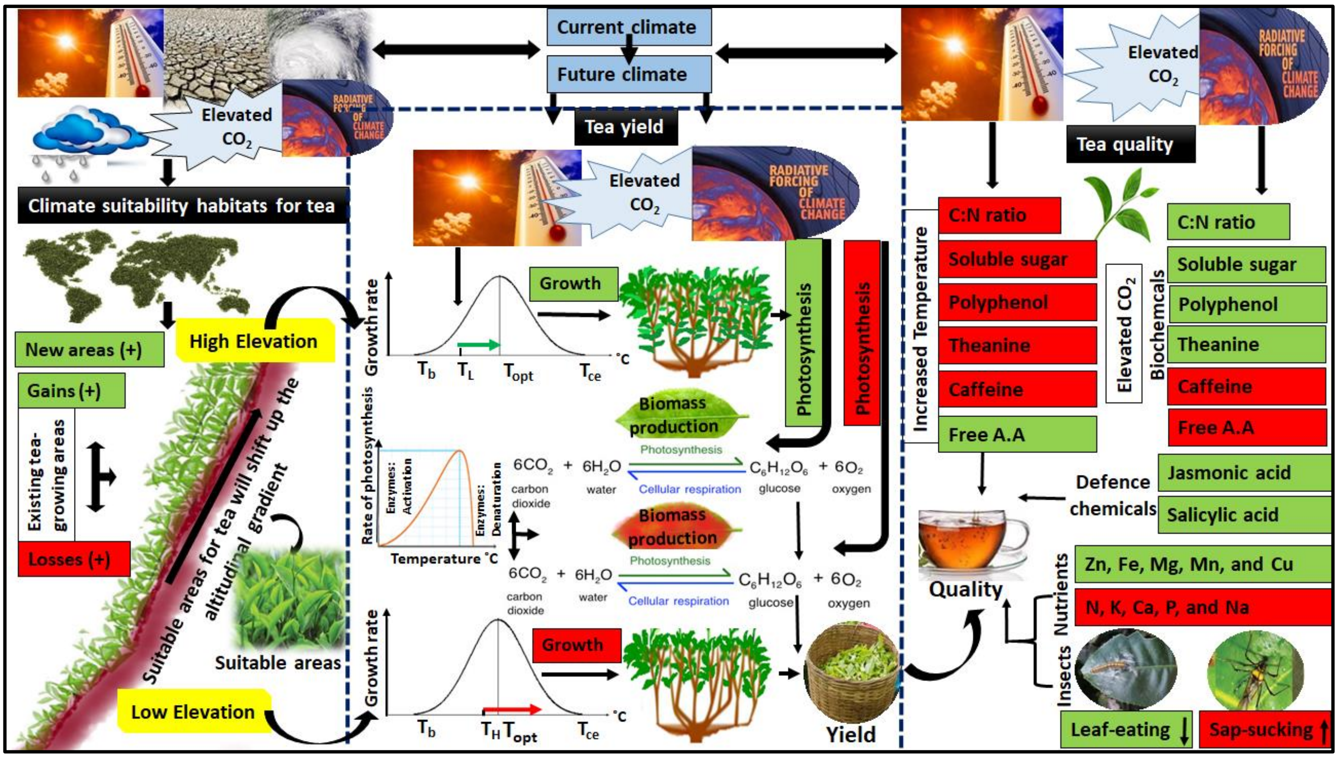


Figure S2. Graphical representation of the overall impact of increased temperature and elevated CO2 on tea yield and quality as well as the impact of the future climate on climate suitability habitats for tea. **Climate suitability for tea:** Major changes in climate suitability for tea in the face of future climate will reduce [loss (-)], increase [gain (+)] of existing areas, and shift climate suitability of tea to new areas. Also, climate suitability at a low elevation will be lost to a greater extent, shifting tea cultivation to high elevations. **Tea yield**: As a C3 plant, elevated CO2 simulates the biomass production of a tea bush via increased photosynthesis and respiration. An increment of the tea yield with elevated CO_2 was further amplified by a rising temperature at high elevations. In contrast, the yield increment with elevated CO_2 is decreased at low elevations since the rising temperature pushed the already high temperature into the ceiling temperature range, which is undesirable for temperature-sensitive enzymes and physiological processes of tea. Overall beneficial impacts of the combined effect of increasing temperature and CO_2 on tea yield would expect in tea-growing areas in low elevation. **Tea quality**: Elevated CO_2 improves some tea quality parameters by enhancing the concentration of biochemicals (C: N ration, Soluble sugar, polyphenol, theanine), defense chemicals (Jasmonic and salicylic acids), nutrients (Zn, Fe, Mg, Mn, and Cu) while suppressing leaf-sucking insects. The impact of rising temperature may results in more negative effects, as reported in our review (T_b- base temperature (temp.), T_o-optimum temp., T_{ce}-ceiling temp., T_L-mean temp. at low elevation, T_H- mean temp. at high elevation). **Note**. The green color boxes indicate the beneficial impact of the future climate, while the red boxes represent negative impacts.

Supplementary Tables

Table S1. Details of reviewers and stakeholders who participated in the present systematic review and their expertise

Names of Reviewers/Stakeholders	Role	Names in the short form	Field of expertise	Team Selection Criteria
Lalit Kumar	Reviewer	LK	Climate modeling, spatial analysis, GIS, and remote sensing	Selecting a review team depends on understanding the research interest of members, the past research experience, available resources, and focusing on reviewing and interpreting the findings [2]. The review team members (SLJ and LK) work in the same institute, where there were multiple opportunities to discuss the focus reviews, exchange ideas, and interpret the results.
Sadeeka Jayasinghe	Reviewer	SLJ	Tea physiology, Agronomy, Species modeling, GIS	
Bhagya Samarasinghe	Stakeholder/Tea chemist	BS	Tea Chemistry, Biochemistry, Food analysis, Plantation management	The RECARE project methodology was used to identify stakeholders [3, 4]. Accordingly, the review team (SLJ and LK) designed the rationale of the study as the initial step. Then, research questions and objectives were developed. After designing the methodology, stakeholders were identified through an initial desk-based search to get their contribution to continue the review process. A team of stakeholders (n=3) were appointed who qualified in our study's major themes, bringing the total team to five members .
Prathibha Kahandage	Stakeholder	PK	Tea quality assurance and certification, Tea tasting (https://lk.linkedin.com/in/prathibha-kahandage-944b4455)	
Chathura Fernando	Stakeholder/ Marketing Executive	CF	Tea Marketing, Exporting, Market Analyst (https://lk.linkedin.com/in/chathura-fernando-4063b2184)	

Table S2. Databases, coding, and search evidence

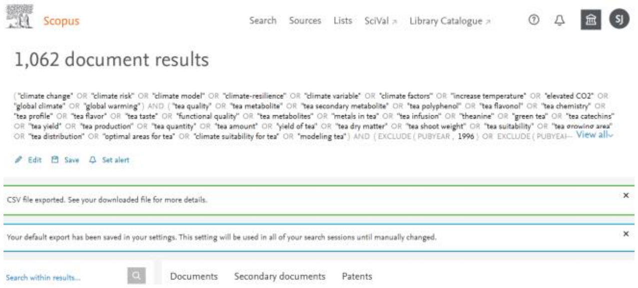
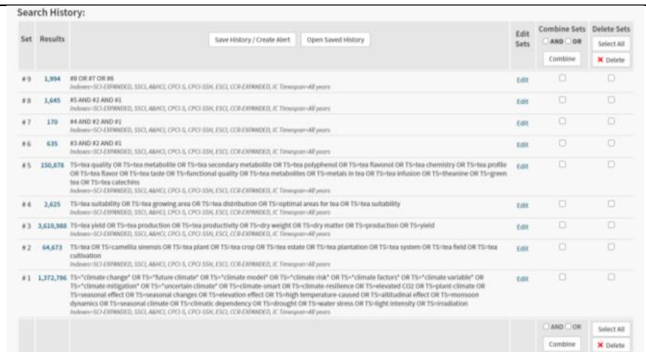
<table>
<tr><th>01. Scopus</th><th>Screen shot of search screen</th></tr>
<tr><td>("climate change" OR "climate risk" OR "climate model" OR "climate-resilience" OR "climate variable" OR "climate factors" OR "increase temperature" OR "elevated CO2" OR "global climate" OR "global warming") AND ("tea quality" OR "tea metabolite" OR "tea secondary metabolite" OR "tea polyphenol" OR "tea flavonol" OR "tea chemistry" OR "tea profile" OR "tea flavor" OR "tea taste" OR "functional quality" OR "tea metabolites" OR "metals in tea" OR "tea infusion" OR "theanine" OR "green tea" OR "tea catechins" OR "tea yield" OR "tea production" OR "tea quantity" OR "tea amount" OR "yield of tea" OR "tea dry matter" OR "tea shoot weight" OR "tea suitability" OR "tea growing area" OR "tea distribution" OR "optimal areas for tea" OR "climate suitability for tea" OR "modeling tea") AND (EXCLUDE (PUBYEAR , 1996) OR EXCLUDE (PUBYEAR , 1990)) AND (EXCLUDE (DOCTYPE , "no") OR EXCLUDE (DOCTYPE , "sh") OR EXCLUDE (DOCTYPE , "ed") OR EXCLUDE (DOCTYPE , "er") OR EXCLUDE (DOCTYPE , "tb"))</td><td>
</td></tr>
<tr><th>02. Web of Science (WoS)</th><th>Screen shot of search screen</th></tr>
<tr><td>TS=*climate change* OR TS=*future climate* OR TS=*climate model* OR TS=*climate risk* OR TS=*climate factors* OR TS=*climate variable* OR TS=*climate mitigation* OR TS=*uncertain climate* OR TS=climate-smart OR TS=climate-resilience OR TS=elevated CO2 OR TS=plant-climate OR TS=seasonal effect OR TS=seasonal changes OR TS=elevation effect OR TS=high temperature-caused OR TS=altitudinal effect OR TS=monsoon dynamics OR TS=seasonal climate OR TS=climatic dependency OR TS=drought OR TS=water stress OR TS=light intensity OR TS=irradiation
TS=tea OR TS=camellia sinensis OR TS=tea plant OR TS=tea crop OR TS=tea estate OR TS=tea plantation OR TS=tea system OR TS=tea field OR TS=tea cultivation
(TS=tea yield OR TS=tea production OR TS=tea productivity OR TS=dry weight OR TS=dry matter OR TS=production OR TS=yield)
TS=tea suitability OR TS=tea growing area OR TS=tea distribution OR TS=optimal areas for tea OR TS=tea suitability
TS=tea quality OR TS=tea metabolite OR TS=tea secondary metabolite OR TS=tea polyphenol OR TS=tea flavonol OR TS=tea chemistry OR TS=tea profile OR TS=tea flavor OR TS=tea taste OR TS=functional quality OR TS=tea metabolites OR TS=metals in tea OR TS=tea infusion OR TS=theanine OR TS=green tea OR TS=tea catechins</td><td>
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Table S3. Details on full-text articles assessed for eligibility for the systematic review

No.	Authors	Title	Key Area	Year	Article Assessed	Records Included/Excluded
1	Ahmed S.	Toward the implementation of climate-resilient tea systems: Agro ecological, physiological, and molecular innovations	Adaptation strategies (AS)	2018	Relevant	Included
2	Qian W., Hu J., Zhang X., Zhao L., Wang Y., Ding Z.	The response of tea plants to drought stress	Adaptation strategies	2018	Relevant	Included
3	Gunathilaka R.P.D., Smart J.C.R., Fleming C.M.	Adaptation to climate change in perennial cropping systems: Options, barriers and policy implications	Adaptation strategies	2018	Relevant	Included
4	Hong N.B., Yabe M.	Improvement in irrigation water use efficiency: a strategy for climate change adaptation and sustainable development of Vietnamese tea production	Adaptation strategies	2017	Relevant	Included
5	Gunathilaka R.P.D., Smart J.C.R., Fleming C.M.	The impact of changing climate on perennial crops: the case of tea production in Sri Lanka	Adaptation strategies	2017	Relevant	Included
6	De Costa W.A.J.M.	Adaptation of agricultural crop production to climate change: A policy framework for Sri Lanka	Adaptation strategies	2010	Relevant	Included
7	Cotrozzi L., Nali C., Pellegrini E., Lorenzini G.	Tea plants and air pollutants	Air pollutants	2018	Relevant	Included
8	Owuor P.O., Wachira F.N., Ng'etich W.K.	Influence of region of production on relative clonal plain tea quality parameters in Kenya	Climate change	2010	Relevant	Included
9	Hao X., Wang L., Zeng J., Yang Y., Wang X.	Response and adaptation mechanisms of tea plant to low-temperature stress	Climate change	2018	Relevant	
10	Li S., Wang Z., Huang J.	Evaluation of tea frost risk in Zhejiang Province based on GIS	Climate change	2018	Relevant	Included
11	Nanglae S., Nilthong R.	Predicting Assam tea distribution in upper northern Thailand using species distribution models	Climate Suitability	2015	Relevant	Included
12	Jayasinghe, SL; Kumar, L; Hasan, MK	Relationship between Environmental Covariates and Ceylon Tea Cultivation in Sri Lanka	Climate Suitability	2020	Relevant	Included
13	Rivera-Parra, JL; Pena-Loyola, PJ	Potential high-quality growing tea regions in Ecuador: an alternative cash crop for Ecuadorian small landholders	Climate Suitability	2020	Relevant	Included
14	Kotikot, SM; Flores, A; Griffin, RE; Nyaga, J; Case, JL; Mugo, R; Sedah, A; Adams, E; Limaye, A; Irwin, DE	Statistical characterization of frost zones: Case of tea freeze damage in the Kenyan highlands	Climate Suitability	2020	Relevant	Included
15	Deng, SR; Lou, WP; Zhao, YM; Sun, K; Chen, KC	Evaluation and spatial distribution of tea plant heat injury risk	Climate Suitability	2020	Relevant	Included
16	Jayasinghe, SL; Kumar, L	Modeling the climate suitability of tea [Camellia sinensis(L.) O. Kuntze] in Sri Lanka in response to current and future climate change scenarios	Climate Suitability	2019	Relevant	Included
17	Jayasinghe, SL; Kumar, L; Sandamali, J	Assessment of Potential Land Suitability for Tea (Camellia sinensis (L.) O. Kuntze) in Sri Lanka Using a GIS-Based Multi-Criteria Approach	Climate Suitability	2019	Relevant	Included
18	Ngoc, HTH; Van, TTT; Ha, NM; Binh, NQ; Tan, MT	Bioclimatic assessments for tea cultivation in Western Nghe An	Climate Suitability	2019	Relevant	Included
19	Ranjitkar, S; Sujakhu, NM; Lu, Y; Wang, Q; Wang, MC; He, J; Mortimer, PE; Xu, JC; Kindt, R; Zomer, RJ	Climate modeling for agroforestry species selection in Yunnan Province, China	Climate Suitability	2016	Relevant	Included
20	Adhikari, U; Nejadhashemi, AP; Woznicki, SA	Climate change and eastern Africa: a review of the impact on major crops	Climate Suitability	2015	Relevant	Included
21	Jayathilaka, PMS; Soni, P; Perret, SR; Jayasuriya, HPW; Salokhe, VM	Spatial assessment of climate change effects on crop suitability for major plantation crops in Sri Lanka	Climate Suitability	2012	Relevant	Included
22	Li, B; Zhang, F; Zhang, LW; Huang, JF; Jin, ZF; Gupta, DK	Comprehensive Suitability Evaluation of Tea Crops Using GIS and a Modified Land Ecological Suitability Evaluation Model	Climate Suitability	2012	Relevant	Included
23	Chang, K., & Brattlof, M.	Contribution of tea production and exports to food security, rural development and smallholder welfare in selected producing countries.	Climate Suitability	2015	Relevant	Included
24	Reay, D.	Climate-smart food	Climate Suitability	2019	Relevant	Included
25	Rigden, AJ; Ongoma, Victor; Huybers, Peter	Kenyan tea is made with heat and water: how will climate change influence its yield?	Climate Suitability	2020	Relevant	Included

26	Laderach, P., & Eitzinger, A.	Report of Future climate scenarios for Kenya tea growing areas CIAT.	Climate Suitability	2011	Relevant	Included
27	Eitzinger, A.,Läderach,., Quiroga,Pantoja, A., & Gordon, J	Future climate scenarios for Uganda's tea growing areas.	Climate Suitability	2011	Relevant	Included
28	Bhagat, R. M., Ahmed, K. Z., Gupta, N., Baruah, R. D., Wijeratne, M. A., Bore, J. K., ... & Ahammed, G. J.	Report of the working group on climate change of the FAO intergovernmental group on tea	Climate Suitability	2016	Relevant	Included
29	Dutta, R.	Monitoring green leaf tea quality parameters of different TV clones grown in northeast India using satellite data.	Climate Suitability	2013	Relevant	Included
30	Kim, Y. K., Jombart, L., Valentin, D., & Kim, K. O.	Familiarity and liking playing a role on the perception of trained panelists: A cross-cultural study on teas	Climate Suitability	2015	Relevant	Included
31	Koo, K. A., Park, S. U., Hong, S., Jang, I., & Seo, C.	Future distributions of warm-adapted evergreen trees, Neolitsea sericea and Camellia japonica under climate change: ensemble forecasts and predictive uncertainty	Climate Suitability	2018	Relevant	Included
32	Sombroek, W. G., & Gommes, R.	The climate change-agriculture conundrum.	Climate Suitability	1996	Relevant	Included
33	Nakao, K., Higa, M., Tsuyama, I., Lin, C. T., Sun, S. T., Lin, J. R., ... & Tanaka, N.	Changes in the potential habitats of 10 dominant evergreen broad-leaved tree species in the Taiwan-Japan archipelago.	Climate Suitability	2014	Relevant	Included
34	Bo, L. I., Zhang, F., ZHANG, L. W., HUANG, J. F., Zhi-Feng, J. I. N., & Gupta, D. K.	Comprehensive suitability evaluation of tea crops using GIS and a modified land ecological suitability evaluation model.	Climate Suitability	2012	Relevant	Included
35	Wickramagamage, P	Large-scale deforestation for plantation agriculture in the hill country of Sri Lanka and its impacts	Climate Suitability	1998	Relevant	Included
36	Zhang, QW; Li, TY; Wang, QS; LeCompte, J; Harkess, RL; Bi, GH	Screening Tea Cultivars for Novel Climates: Plant Growth and Leaf Quality of Camellia sinensis Cultivars Grown in Mississippi, United States	Climate Suitability	2020	Relevant	Included
37	Jayasinghe, S. L., & Kumar, L.	Climate Change May Imperil Tea Production in the Four Major Tea Producers According to Climate Prediction Models	Climate Suitability	2020	Relevant	Included
38	Bore, J. K., & Nyabundi, K. W.	Impact of climate change on tea and adaptation strategies (Kenya)	Climate Suitability	2016	Relevant	Included
39	Sano S., Takemoto T., Ogihara A., Suzuki K., Masumura T., Satoh S., Takano K., Mimura Y., Morita S.	Stress responses of shade-treated tea leaves to high light exposure after removal of shading	Tea Quality	2020	Relevant	Included
40	Zhou W., Liu R., Jiang D., Guo H.	Climate Change and Impact Assessment for the Quality of Guzhang Maojian Tea	Tea Quality	2019	Relevant	Included
41	Li X., Zhang L., Ahammed G.J., Li Y.-T., Wei J.-P., Yan P., Zhang L.-P., Han X., Han W.-Y.	Salicylic acid acts upstream of nitric oxide in elevated carbon dioxide-induced flavonoid biosynthesis in tea plant (Camellia sinensis L.)	Tea Quality	2019	Relevant	Included
42	Kaur L., Donlao N.	Tea antioxidants as affected by environmental factors	Tea Quality	2018	Relevant	Included
43	Li X., Ahammed G.J., Zhang L., Yan P., Zhang L., Han W.-Y	Elevated carbon dioxide-induced perturbations in metabolism of tea plants	Tea Quality	2018	Relevant	Included
44	Wei K., Wang L., Zhou J., He W., Zeng J., Jiang Y., Cheng H.	Catechin contents in tea (Camellia sinensis) as affected by cultivar and environment and their relation to chlorophyll contents	Tea Quality	2011	Relevant	Included
45	Cheruiyot E.K., Mumera L.M., Ng'etich W.K., Hassanali A., Wachira F.	Polyphenols as potential indicators for drought tolerance in tea (Camellia sinensis L.)	Tea Quality	2007	Relevant	Included
46	Ahammed, GJ; Li, X; Liu, AR; Chen, SC	Physiological and Defence Responses of Tea Plants to Elevated CO2: A Review	Tea Quality	2020	Relevant	Included
47	Li, LK; Wang, MF; Pokharel, SS; Li, CX; Parajulee, MN; Chen, FJ; Fang, WP	Effects of elevated CO2 on foliar soluble nutrients and functional components of tea, and population dynamics of tea aphid, Toxoptera aurantii	Tea Quality	2019	Relevant	Included
48	Ahmed, S; Griffin, TS; Kraner, D; Schaffner, MK; Sharma, D; Hazel; Leitch, A; Orians, CM; Han, W; Stepp, JR; Robbat, A; Matyas, ; Long, Xue, DY; Houser, RF; Cash, SB	Environmental Factors Variably Impact Tea Secondary Metabolites in the Context of Climate Change	Tea Quality	2019	Relevant	Included
49	Li, X; Zhang, L; Ahammed, GJ; Li, ZX; Wei, JP; Shen, C; Yan, P; Zhang, LP; Han, WY	Stimulation in primary and secondary metabolism by elevated carbon dioxide alters green tea quality in Camellia sinensis L	Tea Quality	2017	Relevant	Included
50	Jiang, Y., Zhang, S., & Zhang, Q.	Effects of elevated atmospheric CO2 concentration on photo-physiological characteristics of tea plant.	Tea Quality	2005	Relevant	Included

51	Xu, H., Li, L., Li, Q., Zhou, L., Zhu, X., Chen, F., ... & Fang, W.	Effects of elevated atmospheric CO2 concentration and temperature on photosynthesis system and quality components in tea plant.	Tea Quality	2016	Relevant	Included
52	Jiang, Y. L., Zhang, Q. G., & Zhang, S. D.	Effects of atmospheric CO2 concentration on tea quality.	Tea Quality	2006	Relevant	Included
53	Li, X., Ahammed, G. J., Li, Z., Tang, M., Yan, P., & Han, W.	Decreased biosynthesis of jasmonic acid via lipoxygenase pathway compromised caffeine-induced resistance to Colletotrichum gloeosporioides under elevated CO2 in tea	Tea Quality	2016	Relevant	Included
54	Li, X., Zhang, L., Ahammed, G. J., Li, Z. X., Wei, J. P., Shen, C., ... & Han, W. Y.	Stimulation in primary and secondary metabolism by elevated carbon dioxide alters green tea quality in Camellia sinensis L.	Tea Quality	2017	Relevant	Included
55	Coll, M., & Hughes, L.	Effects of elevated CO2 on an insect omnivore: a test for nutritional effects mediated by host plants and prey.	Tea Quality	2008	Relevant	Included
56	Kazan, K.	Plant-biotic interactions under elevated CO2: A molecular perspective	Tea Quality	2018	Relevant	Included
57	Huang, H; Kfoury, N; Orian, CM; Griffin, T; Ahmed, S; Cash, SB; Stepp, JR; Xue, DY; Long, CL; Robbat, A	2014-2016 seasonal rainfall effects on metals in tea (Camelia sinensis (L.) Kuntze)	Tea Quality	2019	Relevant	Included
58	Kfoury, N; Baydakov, E; Gankin, Y; Robbat, A	Differentiation of key biomarkers in tea infusions using a target/nontarget gas chromatography/mass spectrometry workflow	Tea Quality	2018	Relevant	Included
59	Boehm, R; Cash, SB; Anderson, BT; Ahmed, S; Griffin, TS; Robbat, A; Stepp, JR; Han, W; Hazel, M; Orians, CM	Association between Empirically Estimated Monsoon Dynamics and Other Weather Factors and Historical Tea Yields in China: Results from a Yield Response Model	Tea Quality	2016	Relevant	Included
60	Ahmed, S; Stepp, JR; Orians, C; Griffin, T; Matyas, Robbat,; Cash,; Xue,; Unachukwu, U; Buckley, Kennelly, E	Effects of Extreme Climate Events on Tea (Camellia sinensis) Functional Quality Validate Indigenous Farmer Knowledge and Sensory Preferences in Tropical China	Tea Quality	2014	Relevant	Included
61	Xu, W., Song, Q., Li, D., & Wan, X.	Discrimination of the production season of Chinese green tea by chemical analysis in combination with supervised pattern recognition	Tea Quality	2012	Relevant	Included
62	Bhandari, K; De, B; Goswami, TK	Evidence based seasonal variances in catechin and caffeine content of tea	Tea Quality	2019	Relevant	Included
63	Han, WY; Shi, YZ; Ma, LF; Ruan, JY; Zhao, FJ	Effect of liming and seasonal variation on lead concentration of tea plant	Tea Quality	2007	Relevant	Included
64	Hajiboland, R	Environmental and nutritional requirements for tea cultivation	Tea Quality	2017	Relevant	Included
65	Ahmed, S., Peters, C. M., Chunlin, L., Meyer, R., Unachukwu, U., Litt, A., ... & Stepp, J. R.	Biodiversity and phytochemical quality in indigenous and state-supported tea management systems of Yunnan, China.	Tea Quality	2013	Relevant	Included
66	Kfoury, N; Scott, ER; Orians, CM; Ahmed, S; Cash, SB; Griffin, T; Matyas; Stepp, JR; Han; Xue; Long, CL; Robbat,	Plant-Climate Interaction Effects: Changes in the Relative Distribution and Concentration of the Volatile Tea Leaf Metabolome in 2014-2016	Tea Quality	2019	Relevant	Included
67	Li, X; Wei, JP; Ahammed, GJ; Zhang, L; Li, Y; Yan, P; Zhang, LP; Han, WY	Brassinosteroids Attenuate Moderate High Temperature-Caused Decline in Tea Quality by Enhancing Theanine Biosynthesis in Camellia sinensis L.	Tea Quality	2018	Relevant	Included
68	Wang, LY; Wei, K; Jiang, YW; Cheng, H; Zhou, J; He, W; Zhang, CC	Seasonal climate effects on flavanols and purine alkaloids of tea (Camellia sinensis L.)	Tea Quality	2011	Relevant	Included
69	Kfoury, N; Morimoto, J; Kern, A; Scott, ER; Orians, CM; Ahmed, S; Griffin; Cash; Stepp, JR; Xue; Long, CL; Robbat,	Striking changes in tea metabolites due to elevational effects	Tea Quality	2018	Relevant	Included
70	Han, WY; Huang,; Li, X; Li; Ahammed, GJ; Yan, P; Stepp,	Altitudinal effects on the quality of green tea in east China: a climate change perspective	Tea Quality	2017	Relevant	Included
71	Lee, JE; Lee, BJ; Chung, JO; Kim, HN; Kim, EH; Jung, S; Lee, H; Lee, SJ; Hong, YS	Metabolomic unveiling of a diverse range of green tea (Camellia sinensis) metabolites dependent on geography	Tea Quality	2015	Relevant	Included
72	Lee, JE; Lee, BJ; Chung, JO; Hwang, JA; Lee, SJ; Lee, CH; Hong, YS	Geographical and Climatic Dependencies of Green Tea (Camellia sinensis) Metabolites: A H-1 NMR-Based Metabolomics Study	Tea Quality	2010	Relevant	Included
73	Zhang, CY; Yi, XQ; Zhou, F; Gao, XZ; Wang, MH; Chen, JJ; Huang, JN; Shen, CW	Comprehensive transcriptome profiling of tea leaves (Camellia sinensis) in response to simulated acid rain	Tea Quality	2020	Relevant	Included
74	Ahmed, S; Orians, CM; Griffin, TS; Buckley, S; Unachukwu, U; Stratton, AE; Stepp, JR; Robbat, A; Cash, S; Kennelly, EJ	Effects of water availability and pest pressures on tea (Camellia sinensis) growth and functional quality	Tea Quality	2014	Relevant	Included
75	Upadhyaya, H., Dutta, B. K., & Panda, S. K.	Zinc modulates drought-induced biochemical damages in tea [Camellia sinensis (L)	Tea Quality	2013	Relevant	Included

76	Upadhyaya, H., Panda, S. K., & Dutta, B.	CaCl 2 improves post-drought recovery potential in Camellia sinensis (L) O. Kuntze.	Tea Quality	2011	Relevant	Included
77	Cheruiyot, E. K., Mumera, L. M., NG'ETICH, W. K., Hassanali, A., & Wachira, F.	Polyphenols as potential indicators for drought tolerance in tea (Camellia sinensis L.).	Tea Quality	2007	Relevant	Included
78	Cheruiyot, E. K., Mumera, L. M., NG'ETICH, W. K., Hassanali, A., Wachira, F., & Wanyoko, J. K.	Shoot epicatechin and epigallocatechin contents respond to water stress in tea [Camellia sinensis (L.) O. Kuntze].	Tea Quality	2008	Relevant	Included
79	Chakraborty, U., Dutta, S., & Chakraborty, B. N.	The response of tea plants to water stress.	Tea Quality	2002	Relevant	Included
80	Cao, P., Liu, C., & Liu, K.	Aromatic constituents in fresh leaves of Lingtou Dancong tea induced by drought stress.	Tea Quality	2007	Relevant	Included
81	Scott, ER; Li, X; Kfoury, N; Morimoto, J; Han, WY; Ahmed, S; Cash, SB; Griffin, TS; Stepp, JR; Robbat, A; Orians, CM	Interactive effects of drought severity and simulated herbivory on tea (Camellia sinensis) volatile and non-volatile metabolites	Tea Quality	2019	Relevant	Included
82	Nalina, M; Saroja, S; Rajkumar, R; Radhakrishnan, B; Chandrashekara, KN	Variations in quality constituents of green tea leave in response to drought stress under south Indian condition	Tea Quality	2018	Relevant	Included
83	Wang, Y; Fan, K; Wang, J; Ding, ZT; Wang, H; Bi, CH; Zhang, YW; Sun, HW	Proteomic analysis of Camellia sinensis (L.) reveals a synergistic network in response to drought stress and recovery	Tea Quality	2017	Relevant	Included
84	Wang, WD; Xin, HH; Wang, ML; Ma, QP; Wang, L; Kaleri, NA; Wang, YH; Li, XH	Transcriptomic Analysis Reveals the Molecular Mechanisms of Drought-Stress-Induced Decreases in Camellia sinensis Leaf Quality	Tea Quality	2016	Relevant	Included
85	Zhou, L; Xu, H; Mischke, S; Meinhardt, LW; Zhang, DP; Zhu, XJ; Li, XH; Fang, WP	Exogenous abscisic acid significantly affects proteome in tea plant (Camellia sinensis) exposed to drought stress	Tea Quality	2014	Relevant	Included
86	Chaeikar, SS; Marzvan, S; Khiavi, SJ; Rahimi, M	Changes in growth, biochemical, and chemical characteristics and alteration of the antioxidant defense system in the leaves of tea clones under drought stress	Tea Quality	2020	Relevant	Included
87	Zhang, XC; Wu, HH; Chen, JG; Chen, LM; Wan, XC	Chloride and amino acids are associated with K+-alleviated drought stress in tea	Tea Quality	2020	Relevant	Included
88	Li, HJ; Wang, HB; Chen, Y; Ma, QP; Zhao, Z; Li, XH; Chen,X	Isolation and expression profiles of class III PRX gene family under drought stress in tea	Tea Quality	2020	Relevant	Included
89	Zhang, Q., Shi, Y., Ma, L., Yi, X., & Ruan, J	Metabolomic analysis using ultra-performance liquid chromatography-quadrupole-time of flight mass spectrometry (UPLC-Q-TOF MS) uncovers the effects of light intensity and temperature under shading treatments on the metabolites in tea	Tea Quality	2014	Relevant	Included
90	Zheng, X. Q., Jin, J., Chen, H., Du, Y. Y., Ye, J. H., Lu, J. L., ... & Liang, Y. R.	Effect of ultraviolet B irradiation on accumulation of catechins in tea (Camellia sinensis (L) O. Kuntze	Tea Quality	2008	Relevant	Included
91	Li, YC; Jeyaraj, A; Yu, HP; Wang, Y; Ma, QP; Chen, X; Sun, HW; Zhang, H; Ding, ZT; Li, XH	Metabolic Regulation Profiling of Carbon and Nitrogen in Tea Plants [Camellia sinensis (L.) O. Kuntze] in Response to Shading	Tea Quality	2020	Relevant	Included
92	Lu, ZW; Liu, YJ; Zhao, L; Jiang, XL; Li, MZ; Wang, YS; Xu, YJ; Gao, LP; Xia, T	Effect of low-intensity white light mediated de-etiolation on the biosynthesis of polyphenols in tea seedlings	Tea Quality	2014	Relevant	Included
93	Zeng, LT; Watanabe, N; Yang, ZY	Understanding the biosyntheses and stress response mechanisms of aroma compounds in tea (Camellia sinensis) to safely and effectively improve tea aroma	Tea Quality	2019	Relevant	Included
94	Mozumder, NHMR; Lee, YR; Hwang, KH; Lee, MS; Kim, EH; Hong, YS	Characterization of tea leaf metabolites dependent on tea (Camellia sinensis) plant age through H-1 NMR-based metabolomics	Tea Quality	2020	Relevant	Included
95	Fan F.-Y., Li C.-L., Luo Z., Tang G.-Z.	UV-B radiation-induced changes in tea metabolites and related gene expression	Tea Quality	2018	Relevant	Included
96	Yao, L., Caffin, N., D'arcy, B., Jiang, Y., Shi, J., Singanusong, R., ... & Xu, Y.	Seasonal variations of phenolic compounds in Australia-grown tea (Camellia sinensis)	Tea Quality	2005	Relevant	Included
97	Han W.-Y., Li X., Ahammed G.J.	Stress physiology of tea in the face of climate change	Tea Quality and Yeld	2018	Relevant	Included
98	Ahmed S., Griffin T., Cash S.B., Han W.-Y., Matyas C., Long C., Orians C.M., Stepp J.R., Robbat A., Xue D.	Global climate change, ecological stress, and tea production	Tea Quality and Yeld	2018	Relevant	Included
99	Wang Y.-X., Liu Z.-W., Li H., Wang W.-L., Cui X., Zhuang J.	Understanding response of tea plants to heat stress and the mechanisms of adaptation	Tea Quality and Yeld	2018	Relevant	Included
100	Li X., Ahammed G.J., Li Z.-X., Zhang L., Wei J.-P., Yan P., Zhang L.-P., Han W.-Y.	Freezing stress deteriorates tea quality of new flush by inducing photosynthetic inhibition and oxidative stress in mature leaves	Tea Quality and Yeld	2018	Relevant	Included

101	Raj E.E., Kumar R.R., Ramesh K.V.	El niño–southern oscillation (ENSO) impact on tea production and rainfall in south India	Tea Yield	2020	Relevant	Included
102	Muoki C.R., Maritim T.K., Oluoch W.A., Kamunya S.M., Bore J.K.	Combating Climate Change in the Kenyan Tea Industry	Tea Yield	2020	Relevant	Included
103	Marx W., Haunschild R., Bornmann L.	Global warming and tea production-the bibliometric view on a newly emerging research topic	Tea Yield	2017	Relevant	Included
104	Matthews R.B., Stephens W.	Cuppa-tea: A simulation model describing seasonal yield variation and potential production of tea. 1. Shoot development and extension	Tea Yield	1998	Relevant	Included
105	Praveen, B; Sharma, P	Climate variability and its impacts on agriculture production and future prediction using autoregressive integrated moving average method (ARIMA)	Tea Yield	2020	Relevant	Included
106	Rigden, AJ; Ongoma, V; Huybers, P	Kenyan tea is made with heat and water: how will climate change influence its yield?	Tea Yield	2020	Relevant	Included
107	Beringer, T; Kulak, M; Muller, C; Schaphoff, S; Jans, Y	First process-based simulations of climate change impacts on global tea production indicate large effects in the World's major producer countries	Tea Yield	2020	Relevant	Included
108	Ng'etich, W. K., & Stephens, W.	Responses of tea to environment in Kenya. 1. Genotype× environment interactions for total dry matter production and yield.	Tea Yield	2001	Relevant	Included
109	Chen, HY; Liu, CJ; Liu, CF; Hu, CY; Hsiao, MC; Chiou, MT; Su, YS; Tsai, HT	A Growth Model to Estimate Shoot Weights and Leaf Numbers in Tea	Tea Yield	2019	Relevant	Included
110	Raj, EE; Ramesh, KV; Rajkumar, R	Modelling the impact of agrometeorological variables on regional tea yield variability in South Indian tea-growing regions: 1981-2015	Tea Yield	2019	Relevant	Included
111	Sitienei, BJ; Juma, SG; Opere, E	On the Use of Regression Models to Predict Tea Crop Yield Responses to Climate Change: A Case of Nandi East, Sub-County of Nandi County, Kenya	Tea Yield	2017	Relevant	Included
112	Rao, GSLHVP	Weather extremes and plantation crops in the humid tropics	Tea Yield	2016	Relevant	Included
113	Dutta, R	Climate change and its impact on tea in Northeast India	Tea Yield	2014	Relevant	Included
114	Murugan, M; Shetty, PK; Ravi, R; Anandhi, A; Rajkumar,	Climate change and crop yields in the Indian Cardamom Hills, 1978-2007 CE	Tea Yield	2012	Relevant	Included
115	Wijeratne, M. A., Anandacoomaraswamy, A., Amarathunga, M. K. S. L. D., Ratnasiri, J., Basnayake, B. R. S. B., & Kalra, N.	Assessment of impact of climate change on productivity of tea (Camellia sinensis L.) plantations in Sri Lanka.	Tea Yield	2007	Relevant	Included
116	Jayasinghe, H. A. S. L., Suriyagoda, L. D. B., Karunarathne, A. S., & Wijeratna, M. A.	Modelling shoot growth and yield of Ceylon tea cultivar TRI-2025 (Camellia sinensis (L.) O. Kuntze).	Tea Yield	2018	Relevant	Included
117	Okoth, George K	Potential response of Tea production to climate change in Kericho County	Tea Yield	2011	Relevant	Included
118	Leary, N., Conde, C., & Kulkarni, J.	Climate change and vulnerability.	Tea Yield	2009	Relevant	Included
119	Nowogrodzki, A.	The changing seasons of tea	Tea Yield	2019	Relevant	Included
120	De Costa, W. A., Mohotti, A. J., & Wijeratne, M. A.	Ecophysiology of tea	Tea Yield	2007	Relevant	Included
121	Ochieng, J., Kirimi, L., & Mathenge, M.	Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya	Tea Yield	2016	Relevant	Included
122	Wijeratne, MA	Vulnerability of Sri Lanka tea production to global climate change	Tea Yield	1996	Relevant	Included
123	Biggs, EM; Gupta, N; Saikia, SD; Duncan, JMA	The tea landscape of Assam: Multi-stakeholder insights into sustainable livelihoods under a changing climate	Tea Yield	2018	Relevant	Included
124	Gunathilaka, RPD; Smart, JCR; Fleming, CM	The impact of changing climate on perennial crops: the case of tea production in Sri Lanka	Tea Yield	2017	Relevant	Included
125	Duncan, JMA; Saikia, SD; Gupta, N; Biggs, EM	Observing climate impacts on tea yield in Assam, India	Tea Yield	2016	Relevant	Included
126	Adhikari, U; Nejadhashemi, AP; Woznicki, SA	Climate change and eastern Africa: a review of impact on major crops	Tea Yield	2015	Relevant	Included
127	Lou, WP; Sun, K; Zhao, YM; Deng, SR; Zhou, ZD	Impact of climate change on inter-annual variation in tea plant output in Zhejiang, China	Tea Yield	2020	Relevant	Included
128	Carr, MKV	Evaluating the impact of research for development: Tea in Tanzania	Tea Yield	1999	Relevant	Included

129	STEPHENS, W; OTHIENO, CO; CARR, MKV	Climate and weather variability at the Tea-research foundation of Kenya	Tea Yield	1992	Relevant	Included
130	Wu, YZ; Li, Y; Fu, XQ; Shen, JL; Chen, D; Wang, Y; Liu, XL; Xiao, RL; Wei, WX; Wu, JS	Effect of controlled-release fertilizer on N2O emissions and tea yield from a tea field in subtropical central China	Tea Yield	2018	Relevant	Included
131	Wang, WQ; Min, QW; Sardans, J; Wang, C; Asensio, D; Bartrons, M; Penuelas, J	Organic Cultivation of Jasmine and Tea Increases Carbon Sequestration by Changing Plant and Soil Stoichiometry	Tea Yield	2016	Relevant	Included
132	Azapagic, A; Bore, J; Cheserek, B; Kamunya, S; Elbehri, A	The global warming potential of production and consumption of Kenyan tea	Tea Yield	2016	Relevant	Included
133	Wu, Y., Li, Y., Fu, X., Shen, J., Chen, D., Wang, Y., & Wu, J.	Effect of controlled-release fertilizer on N2O emissions and tea yield from a tea field in subtropical central China.	Tea Yield	2018	Relevant	Included
134	Hu, AH; Chen, CH; Huang, LH; Chung, MH; Lan, YC; Chen, ZH	Environmental Impact and Carbon Footprint Assessment of Taiwanese Agricultural Products: A Case Study on Taiwanese Dongshan Tea	Tea Yield	2019	Relevant	Included
135	Hong, NB; Yabe, M	Improvement in irrigation water use efficiency: a strategy for climate change adaptation and sustainable development of Vietnamese tea production	Tea Yield	2017	Relevant	Included
136	Baruah, R. D., Roy, S., Bhagat, R. M., & Sethi, L. N	Use of data mining technique for prediction of tea yield in the face of climate change of Assam, India.	Tea Yield	2016	Relevant	Included
137	Li X., Li M.-H., Deng W.-W., Ahammed G.J., Wei J.-P., Yan P., Zhang L.-P., Fu J.-Y., Han W.-Y.	Exogenous melatonin improves tea quality under moderate high temperatures by increasing epigallocatechin-3-gallate and theanine biosynthesis in Camellia sinensis L.		2020	Article not relevant to the topics/objectives	Excluded
138	Wang Y., Yao Z., Pan Z., Wang R., Yan G., Liu C., Su Y., Zheng X., Butterbach-Bahl K.	Tea-planted soils as global hotspots for N2O emissions from croplands		2020	Article not relevant to the topics/objectives	Excluded
139	Phan P., Chen N., Xu L., Chen Z.	Using multi-temporal MODIS NDVI data to monitor tea status and forecast yield: A case study at Tanuyen, Laichau, Vietnam		2020	Article not relevant to the topics/objectives	Excluded
140	Haque S., Akbar D., Kinnear S.	The variable impacts of extreme weather events on fruit production in subtropical Australia		2020	Article not relevant to the topics/objectives	Excluded
141	Rezamela E., H Syahrian K., Wulansari R., Prawira-Atmaja M.I., Agustian E., Adilina I.B.	Polyphenols Content of Indonesian Tea Clones on Optimum Manuring Condition		2020	Article not relevant to the topics/objectives	Excluded
142	Baruah U.D., Mili N., Basumatary M., Saikia A.	Assessment of spatial pattern and distribution of major crops in Assam, India		2020	Article not relevant to the topics/objectives	Excluded
143	Rahimi M., Kordrostami M., Mortezavi M.	Evaluation of tea (Camellia sinensis L.) biochemical traits in normal and drought stress conditions to identify drought tolerant clones		2019	Article not relevant to the topics/objectives	Excluded
144	Scott E.R., Li X., Kfoury N., Morimoto J., Han W.-Y., Ahmed S., Cash S.B., Griffi, Stepp, Robbat A., Jr., Orians	Interactive effects of drought severity and simulated herbivory on tea (Camellia sinensis) volatile and non-volatile metabolites		2019	Article not relevant to the topics/objectives	Excluded
145	Hu A.H., Chen C.-H., Huang L.H., Chung M.-H., Lan Y.-C., Chen Z.	Environmental impact and carbon footprint assessment of taiwanese agricultural products: A case study on taiwanese dongshan tea		2019	Article not relevant to the topics/objectives	Excluded
146	Samarina L.S., Ryndin A.V., Malyukova L.S., Gvasaliya M.V., Malyarovskaya V.I.	Physiological mechanisms and genetic factors of the tea plant Camellia sinensis (L.) Kuntze response to drought (review)		2019	Article not relevant to the topics/objectives	Excluded
147	Kim, YG	Tide status and prospect of Korean green tea industry	Tides on tea industry	2000	Full text paper was not accessible	Excluded
148	Cotrozzi L., Landi M.	Molecular and physiological adaptations of tea plant in response to low light and UV stress		2018	Article not relevant to the topics/objectives	Excluded
149	Hajiboland R.	Nutrient deficiency and abundance in tea plants: Metabolism to productivity		2018	Article not relevant to the topics/objectives	Excluded
150	Zhang L., Ahammed G.J., Li X., Yan P., Zhang L., Han W.-Y.	Plant hormones as mediators of stress response in tea plants		2018	Article not relevant to the topics/objectives	Excluded
151	Haorongbam N.S., Rout J., Sethi L.N.	Heavy metal occurrence in the soil of high input tea agroecosystem of southern Assam, Northeast India		2018	Article not relevant to the topics/objectives	Excluded

152	Koech R.K., Malebe P.M., Nyarukowa C., Mose R., Kamunya S.M., Apostolides Z.	Identification of novel QTL for black tea quality traits and drought tolerance in tea plants (Camellia sinensis)		2018	Article not relevant to the topics/objectives	Excluded
153	Oo A.Z., Sudo S., Akiyama H., Win K.T., Shibata A., Yamamoto A., Sano T., Hirono Y.	Effect of dolomite and biochar addition on N2O and CO2 emissions from acidic tea field soil		2018	Article not relevant to the topics/objectives	Excluded
154	Chen D., Li Y., Wang C., Fu X., Liu X., Shen J., Wang Y., Xiao R., Liu D.L., Wu J.	Measurement and modeling of nitrous and nitric oxide emissions from a tea field in subtropical central China		2017	Article not relevant to the topics/objectives	Excluded
155	Kottawa-Arachchi J.D., Wijeratne M.A.	Climate change impacts on biodiversity and ecosystems in Sri Lanka: A review		2017	Article not specifically relevant to tea	Excluded
156	Sumadio W., Andriesse E., Aprilianti F., Sulyat A.	Droughts and debts: The domestic tea value chain and vulnerable livelihoods in Girimukti village, West Java, Indonesia		2017	Article not relevant to the topics/objectives	Excluded
157	Kalita R.M., Das A.K., Nath A.J.	Allometric equations for estimating above- and belowground biomass in Tea (Camellia sinensis (L.) O. Kuntze) agroforestry system of Barak Valley, Assam, northeast India		2015	Article not relevant to the topics/objectives	Excluded
158	Lou W., Sun S., Wu L., Sun K.	Effects of climate change on the economic output of the Longjing-43 tea tree, 1972–2013		2014	Article not specifically relevant to tea	Excluded
159	Ahmed S., Orians C.M., Griffin T.S., Buckley, Unachukwu U., Stratton A.E, Stepp J.R., Robbat A., Cash S., Kennelly	Effects of water availability and pest pressures on tea (Camellia sinensis) growth and functional quality		2014	Article not relevant to the topics/objectives	Excluded
160	Han W., Xu J., Wei K., Shi Y., Ma L.	Estimation of N2O emission from tea garden soils, their adjacent vegetable garden and forest soils in eastern China		2013	Article not relevant to the topics/objectives	Excluded
161	Kumar S., Paul A., Bhattacharya A., Sharma R.K., Ahuja P.S.	Tea: Present Status and Strategies to Improve Abiotic Stress Tolerance		2012	Article not relevant to the topics/objectives	Excluded
162	Satake A., Ohgushi T., Urano S., Uchimura K.	Modeling population dynamics of a tea pest with temperature-dependent development: Predicting emergence timing and potential damage		2006	Article not relevant to the topics/objectives	Excluded

Table S4. Impacts of current and future climate on tea yield

No.	Authors	Article Title	Year	Climatic Factors	Country	Key Findings
1	Praveen, B; Sharma, P	Climate variability and its impacts on agriculture production and future prediction using an autoregressive integrated moving average method (ARIMA)	2020	Temperature	India	Praveen and Sharma (2020) assessed the impacts of climate variation on land productivity for major crops using data for 50 years (1967–2016). They found that as temperature increases, the production of tea slightly increases or decreases.
2	Rigden, AJ; Ongoma, V; Huybers, P	Kenyan tea is made with heat and water: how will climate change influence its yield?	2020	Temperature	Kenya	Ridgen et al. (2020) used satellite-derived observations to characterize the response of tea yield to water and heat stress from 2008 to 2016 across Kenya. They found that yields in 2040-2070 would decrease by only 5%, considering rising temperature and soil moisture.
3	Beringer, T; Kulak, M; Muller, C; Schaphoff, S; Jans, Y	First process-based simulations of climate change impacts on global tea production indicate large effects in the World's major producer countries	2020	Temperature	Major tea-producing countries	Beringer et al. (2019) predicted the impacts of climate change on global tea production using the dynamic global vegetation model with managed land, LPJmL4 in Five different GCMs (i.e., HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, GFDL-ESM2M, and NorESM1-M) using four RCPs corresponding global surface air temperature of 1 °C (RCP2.6), 1.8 °C (RCP4.5), 2.2 °C (RCP6.0) and 3.7 °C (RCP8.5) by 2081–2100 relative to the 1986–2005 reference period (IPCC 2013). Beringer et al. (2019) indicated that yield reductions would occur under RCP2.6, whereas tea yields increase under more extreme climates in most regions in the future (2069-2099). In China, Japan, Turkey, and Vietnam, increased yields are projected under all climate change scenarios. On average, across all regions, yields increase by 2%, 14%, 20%, and 27% under RCP2.6, RCP4.5, RCP6.0, and RCP8.5, respectively. Indonesia, Kenya, Sri Lanka, and to some extent, Bangladesh are projected to see substantial yield declines under some climate scenarios (Beringer et al. 2019).
4	Ng'etich, W. K., & Stephens, W.	Responses of tea to environment in Kenya. 1. Genotype× environment interactions for total dry matter production and yield.	2001	Temperature	Kenya	Large responses to the environment in dry matter production and yield were found. In general, the mean yield and DM production increased with the higher temperatures in the lower altitude sites. The clear reduction in yield at higher altitudes implies that management targets and decisions should be modified to reflect the smaller potential yield at higher altitudes. There might also be implications in terms of the value of land where the yield potential is low.
5	Chen, HY; Liu, CJ; Liu, CF; Hu, CY; Hsiao, MC; Chiou, MT; Su, YS; Tsai, HT	A Growth Model to Estimate Shoot Weights and Leaf Numbers in Tea	2019	Temperature and Solar radiation	Taiwan	Chen et al. (2019) estimated the relationship between solar radiations, air temperature, and tea yield in Taiwan. They found that number of leaves and weight of tea shoots increase with unit increment of solar radiation for air temperatures. This parametrized model can be used to predict tea yield.
6	Raj, EE; Ramesh, KV; Rajkumar, R	Modelling the impact of agrometeorological variables on regional tea yield variability in South Indian tea-growing regions: 1981-2015	2019	Temperature and Rainfall	India	Raj et al. (2019) assessed the relations between meteorological factors and yield variability utilizing observed climate data for the period 1981–2015 in the South Indian Tea Growing Regions using a different empirical statistical approach. There has been a significant reduction in tea productivity in the recent past due to the changes in temperature and rainfall patterns.
7	Hajiboland, R	Environmental and nutritional requirements for tea cultivation	2017	Temperature, Rainfall, Drought	Review - World context	Tea yield is sensitive to temperatures, and higher temperatures reduce tea yield—uneven rainfall distribution limits annual tea yield (Hajiboland, 2017). Drought is responsible for a 14-20% reduction in yield and 6-19% mortality of tea plants (Cheruiyot et al. 2008). In drought conditions, photoinhibition could reduce source capacity and thereby reduce tea yield (Mohotti and Lawlor 2002), Shoot extension rate, harvestable shoot density (Nsh), shoot weight (Wsh), and shoot ψw of tea were significantly reduced when Soil water deficits (SWD) exceeded 30-40 mm (Wijeratne and Fordham 1996). The critical shoot water potential for a reduction in tea yield is around –0.7 to –0.8 MPa (Carr 2010)., Wijeratne et al. (2007a) showed that an increase in CO2 from the present ambient level of 370 μmol mol-1 to 600 μmol mol-1 increased tea yields by 33 and 37% at the high and low elevations, respectively.
8	Sitienei, BJ; Juma, SG; Opere, E	On the Use of Regression Models to Predict Tea Crop Yield Responses to Climate Change: A Case of Nandi East, Sub-County of Nandi County, Kenya	2017	Temperature Rainfall	Kenya	Sitienei et al. (2017) attempted to use a regression model to predict the yield of tea in Kenya based on changes in maximum, minimum temperature, and precipitation. They found a general increasing trend in the tea yield, which indicates improving yield over time; however, the regressions were weak.

9	Rao, GSLHVP	Weather extremes and plantation crops in the humid tropics	2016	Temperature and Humidity	India	Rao. (2016) indicated If night temperature drops below 5˚C and humidity below 10% lead to a lower level of tea production, while heatwave also adversely affected tea crops up to 50 % in Himachal Pradesh, India.
10	Dutta, R	Climate change and its impact on tea in Northeast India	2014	Temperature, Rainfall	India	Dutta (2014) showed the possibility of an increase in average temperature by 2 ˚C in 2050, while not much variation is observed in the rainfall pattern, which will cause a shift in the peak production period by 2050. The CUPPA Tea simulation model (Matthews & Stephens 1998) simulates the growth and yield of tea considering the effects of solar radiation, atmospheric humidity, temperature, day length, and soil water availability
11	Murugan, M; Shetty, PK; Ravi, R; Anandhi, A; Rajkumar, AJ	Climate change and crop yields in the Indian Cardamom Hills, 1978-2007 CE	2012	Temperature, Rainfall	India	Murugan et al. (2011) analyzed climate and crop yield data from Indian cardamom hills for the period 1978–2007, and the observed increases in temperature coupled with a change in rainfall pattern did not increase the tea yield, and the yield productivity of tea crop has been stagnant during our study period.
12	Wijeratne, M. A., Anandacoomaraswamy, A., Amarathunga, M. K. S. L. D., Ratnasiri, J., Basnayake, B. R. S. B., & Kalra, N.	Assessment of impact of climate change on productivity of tea (Camellia sinensis L.) plantations in Sri Lanka.	2007	Temperature, Rainfall, Drought, Water deficit, CO2	Sri Lanka	The study indicated that reduction of monthly rainfall by 100 mm could reduce the productivity by 30 - 80 kg of 'made' tea ha". The optimum rainfall for tea cultivation varied from 223 to 417 mm per month. Increase C02 concentration from the present 370 ppm to 600 ppm, increased the tea yield by about 33-37 % depending on the elevation. Yield projections that rising temperatures and diminishing rainfall reduce tea yield in many tea-growing regions except Wet zone Upcountry (WU). The results also predicted that tea yields are likely to increase at high elevations while the yields at low elevations.
13	Okoth, George K	Potential response of Tea production to climate change in Kericho County	2011	Temperature, Rainfall	Kenya	The climate projections from the simulated climate scenarios A2 for the Kericho area in Kenya showed that the increased rainfall and minimum temperature, especially for the long-term period around 2070 had the potential to increase tea yield, while an increase in maximum temperature was found to create a potential decrease in tea yield.
14	Leary, N., Conde, C., & Kulkarni, J.	Climate change and vulnerability.	2009	Temperature, Rainfall	World context	Projections of future climate change indicate warmer temperatures and both increases and decreases in precipitation. In the low-elevated tea growing areas, where temperatures are near the optimum for tea yields, warming would decrease yields. In the cooler uplands, tea yields would increase with warming.
15	Nowogrodzki, A.	The changing seasons of tea	2019	Temperature, Season	India, China	Exposure of tea plants to sunlight, which can damage crops, is increasing in both China and Assam. Increasing temperature also reduces the tea yield in both India and China. A shift in the seasons can lead to a shorter growing season for tea, which reduces yields of the first flush and the second flush in plantations in Assam, India.
16	De Costa, W. A., Mohotti, A. J., & Wijeratne, M. A.	Ecophysiology of tea	2007	Temperature, Rainfall, Drought, Water deficit	Discussion paper : Sri Lanka	Tea yields respond significantly to irrigation, a promising option to increase productivity during dry periods. In environments with only a small proportion of clear, sunny days per year, giving too much shade could cause yield reductions due to reduced radiation. The yield of a temperature-sensitive cultivar decreased significantly with increasing altitude while that of the other temperature-insensitive cultivar remained stable until an altitude of 2120 m was exceeded.
17	Ochieng, J., Kirimi, L., & Mathenge, M.	Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya	2016	Temperature, Rainfall	Kenya	They investigated how climate variability and change affect agricultural production, but effects differ across crops. The temperature has a positive impact on tea yield, while rainfall has a negative impact on tea. Climate change will affect agriculture in 2020, 2030, and 2040 with greater effects in the tea sector.
18	Wijeratne, MA	Vulnerability of Sri Lanka tea production to global climate change	1996	Temperature, Soil water deficit, drought	Sri Lanka	Wijeratne (1996) stated that increases in temperature, soil moisture deficit, and saturation vapor pressure deficit in the low elevations would adversely affect tea's growth and yield. The tea industry in Sri Lanka is vulnerable to predicted climate changes
19	Biggs, EM; Gupta, N; Saikia, SD; Duncan, JMA	The tea landscape of Assam: Multi-stakeholder insights into sustainable livelihoods under a changing climate	2018	Rainfall, Drought, Temperature	India	Biggs et al. (2018) stated that 97% of smallholders also noted that adverse climate conditions reduce the yield quantity of tea in Assam, India. Periods of drought can lead to reduced yield (Dikshit and Dikshit, 2014). Duncan et al. (2016) showed that prolonged periods of no precipitation reduce tea yields.
20	Gunathilaka, RPD; Smart, JCR; Fleming, CM	The impact of changing climate on perennial crops: the case of tea production in Sri Lanka	2017	Rainfall, Drought, Temperature	Sri Lanka	Gunathilake et al. (2017), under the medium emissions scenario (A1B), tea production is predicted to decline by around 7.7% across all three elevations. In the medium term, this increases to 10.7%, and by the end of the century to 22%. Also, averaged across all elevations, a 1 °C increase in average temperature will cause a 4.6% reduction in tea yield. Similarly, an additional 100 mm of annual rainfall decreases tea production by around 1%. Further, tea production will reduce by 3.5% if there is one less wet day per month.
21	Duncan, JMA; Saikia, SD; Gupta, N; Biggs, EM	Observing climate impacts on tea yield in Assam, India	2016	Rainfall, Drought, Temperature	India	Duncan et al. (2016) showed decreasing tea yield due to increased monthly precipitation. They found decreasing tea yield returns to warmer monthly average temperatures, and when monthly temperatures were above 26.6 C, warming had a negative effect. They found that drought intensity did not affect tea yield and that precipitation variability, particularly precipitation intensity, negatively affected tea yield.

22	Boehm, R; Cash, SB; Anderson, BT; Ahmed, S; Griffin, TS; Robbat, A; Stepp, JR; Han, W; Hazel, M; Orians, CM	Association between Empirically Estimated Monsoon Dynamics and Other Weather Factors and Historical Tea Yields in China: Results from a Yield Response Model	2016	Rainfall, Season and Solar radiation	China	Bohem et al. (2016) found that a 1% increase in the monsoon retreat date is associated with a 0.481%–0.535% reduction in tea yield while a 1% increase in the monsoon's date retreat is associated with a 0.604% decrease in tea yields. A 1% increment in average daily precipitation occurring during the monsoon period is associated with a 0.184%–0.262% yield reduction, while 1% increase in the average daily monsoon precipitation from the previous growing season is associated with a 0.258%–0.327% decline in yields. They also found that a 1% decrease in solar radiation in the previous growing season is associated with 0.554%-0.864% yield reduction.
23	Adhikari, U; Nejadhashemi, AP; Woznicki, SA	Climate change and eastern Africa: a review of impact on major crops	2015	Rainfall	Africa	Due to the uncertainty of uniform rainfall and spatial rainfall in rainfall, tea yield in eight sub-Saharan Africa is negatively affected.
24	Lou, WP; Sun, K; Zhao, YM; Deng, SR; Zhou, ZD	Impact of climate change on inter-annual variation in tea plant output in Zhejiang, China	2020	Season	China	Lou et al. (2020) found that high temperature and drought were the main factors that reduced the tea yield in summer and autumn and affected the economic output of tea in spring in the following year. The economic losses caused by daytime rainfall decreased significantly in tea production in the spring season.
25	Carr, MKV	Evaluating the impact of research for development: Tea in Tanzania	1999	Drought	Tanzania	Carr (1998) quantified the effects of drought on the productivity of clonal tea and the likely responses of yield to irrigation and fertilizer applications.
26	Stephens, W; Othieno, CO; Carr, MKV	Climate and weather variability at the Tea-research foundation of Kenya	1992	Drought	Kenya	Carr (1998) quantified the effects of drought and water deficit on tea yields. Storms cause yield losses owing to hail damage (Stephens et al. 1992).
27	Ahammed, GJ; Li, X; Liu, AR; Chen, SC	Physiological and Defense Responses of Tea Plants to Elevated CO2: A Review	2020	CO2	Review - World context	Ahmed et al. (2020) showed mentioned that elevated CO2 promotes tea yield, but it attenuates tea plant resistance to some insects and pathogens, which poses a serious threat to future tea production systems.
28	Li, L., Wang, M., Pokharel, S. S., Li, C., Parajulee, M. N., Chen, F., & Fang, W.	Effects of elevated CO2 on foliar soluble nutrients and functional components of tea, and population dynamics of tea aphid, Toxoptera aurantii.	2019	CO2	China	Elevated CO2 enhanced the photosynthesis, growth, and biomass of tea seedlings compared with ambient CO2.
29	Li, X., Zhang, L., Ahammed, GJ., Li, Z. Wei, J. P.. & Han, W. Y.	Stimulation in primary and secondary metabolism by elevated CO2 alters green tea quality in Camellia sinensis L.	2017	CO2	China	Exposure of tea plants to elevated CO2 (800 µmol mol-1 for 24 d) remarkably improved photosynthesis and respiration, thereby biomass in tea leaves.
30	Jiang, Y., Zhang, S., & Zhang, Q	Effects of elevated atmospheric CO2 concentration on photo-physiological characteristics of tea plant.	2005	CO2	China	Jiang et al. (2005) showed that elevated CO2 increases the tea yield and effect of the tea plants' defense mechanism.
31	Wu, YZ; Li, Y; Fu, XQ; Shen, JL; Chen, D; Wang… Wu, JS	Effect of controlled-release fertilizer on N2O emissions and tea yield in subtropical central China	2018	CO2 and N2O	China	N2O global warm potential is approximately 300 times higher than CO2. Wu et al. (2018) showed that N fertilization is the main source of N2O emissions, and the application of high rates of controlled-release N fertilizer will reduce tea yield by 6.8%.
32	Wang, WQ; Min, QW; Sardans, J; Wang, C; Asensio, . M; Penuelas,	Organic Cultivation of Jasmine and Tea Increases Carbon Sequestration by Changing Plant and Soil Stoichiometry	2016	CO2 sequestration	China	Wang et al. (2016) suggested that organic cultivation could increase the overall CO2 sequestration, thereby mitigating climate change and enhancing soil nutrient content.
33	Azapagic, A; Bore, J; Cheserek, B; Kamunya, S; Elbehri, A	The global warming potential of production and consumption of Kenyan tea	2016	CO2 sequestration	Kenya	Azapagic et al. (2015) found that deforestation diminishes the carbon sequestration potential and could make tea cultivation more vulnerable to climate change in the future.
34	Wu, Y., Li, Y., Fu, X., Shen, J., Chen, D., Wang, Y., ... & Wu, J.	Effect of controlled-release fertilizer on N2O emissions and tea yield from a tea field in subtropical central China.	2018	N2O emission	China	Overall, yield-scaled N2O emissions of tea were reduced by 44.5% ($p > 0.05$) under CRF50% and significantly increased by 100% ($p < 0.05$) under CRF100%. Based on the gross margin analysis, CRF50% obtained the highest net economic profit.
35	Hu, AH; Chen, CH; Huang, LH; Chung, MH; Lan, YC; Chen, ZH	Environmental Impact and Carbon Footprint Assessment of Taiwanese Agricultural Products: A Case Study on Taiwanese Dongshan Tea	2019	Greenhouse gas (GHG)	China	Hu et al. (2019) stated that agriculture aggravates climate change by increasing greenhouse gas (GHG) emissions, and in response, climate change reduces agricultural productivity.
36	Hong, NB; Yabe, M	Improvement in irrigation water use efficiency: a strategy for climate change adaptation and sustainable development of Vietnamese tea production	2017	Water content with Climate Change	Vietnam	With the severe scarcity of water resources because of climate change, water conservation through efficient irrigation has turned into a vital strategy for the tea sector. The study' results provide insights to policymakers in implementing better water resource management amid climate change (Bich Hong and Yabe, 2016).

37	Baruah, R. D., Roy, S., Bhagat, R. M., & Sethi, L. N	Use of data mining technique for prediction of tea yield in the face of climate change of Assam, India.	2016	All climatic factors	India	The tea production estimation equations developed for the regions were validated for the future yield prediction (2007, 2009, and 2010) and were found to be significant.
38	Muoki C.R., Maritim T.K., Oluoch W.A., Kamunya S. Bore J.K.	Combating Climate Change in the Kenyan Tea Industry	2020	All climatic factors	Kenya	Muoki et al. (2020) reviewed simulation models and climate scenarios required to quantify tea production in Kenya. They suggested the importance of implementing adaptation and mitigation strategies to combat the adverse impact of climate change.
39	Marx W., Haunschild R., Bornmann L.	Global warming and tea production-the bibliometric view on a newly emerging research topic	2017	All climatic factors	Review - World context	Climate change and tea production is an emerging discussion on climate change impacts and adaptation strategies. Questions regarding the historical context of research fields or specific research topics can be answered by using a bibliometric method called "Reference Publication Year Spectroscopy" (RPYS)
40	Raj E.E., Kumar R.R., Ramesh K.V.	El niño–southern oscillation (ENSO) impact on tea production and rainfall in south India	2020	El Niño–Southern Oscillation (ENSO)	India	Phan et al. (2020) made an effort to investigate the impact of El Niño–Southern Oscillation (ENSO) which is caused by oscillation of sea surface temperature (SST). This phenomenon induced inter-annual rainfall fluctuations in south India (SI) that impact tea yield, and the correlation between rainfall and crop yield for 1971-2015 ($r = 0.045$) is positively weak.
41	Jayasinghe, H. A. S. L., Suriyagoda, L. D. B., Karunarathne, A. S., & Wijeratna, M. A.	Modeling shoot growth and yield of Ceylon tea cultivar TRI-2025 (Camellia sinensis (L.) O. Kuntze).	2018	Modeling: Temperature, Rainfall, Solar radiation	Sri Lanka	This study was aimed at stimulating the growth and yield of Sri Lankan tea cultivar TRI 2025 grown in different climatic regions in the country. The model was developed and calibrated using weather, crop, and soil data collected from different climatic zones.
42	Matthews R.B., Stephens W.	Cuppa-tea: A simulation model describing seasonal yield variation and potential production of tea. 1. Shoot development and extension	1998	Modeling using; Temperature, Rainfall, Solar radiation	Tanzania	Matthews and Stephens (1998) developed a simulation model describing the growth and yield of tea (Camellia sinensis L.), and good validation results were found between model predictions and observed yields for well-irrigated tea in the Southern Highlands of Tanzania.

Table S5. Impacts of current and future climate on tea quality

No.	Authors	Article Title	Year	Climatic Variable	Country	Key Findings
1	Ahammed, GJ; Li, X; Liu, AR; Chen, SC	Physiological and Defense Responses of Tea Plants to Elevated CO2: A Review	2020	CO2	Review: World context	Elevated CO2 alters the tea quality by differentially influencing the concentrations and biosynthetic gene expression of tea polyphenols, free amino acids, catechins, theanine, and caffeine. Signaling molecules salicylic acid and nitric oxide function in a hierarchy to mediate the elevated CO2-induced flavonoid biosynthesis in tea leaves. Despite enhanced synthesis of defense compounds, tea plant defense to some insects and pathogens is compromised under elevated CO2 (Ahamed et al. 2020). ü It is inferred that with increasing CO2, the adversities of extreme climate events such as heatwave, drought, and frost will be increasing (Li et al., 2018, 2019a; Ahmed et al., 2019). ü Climate changes differentially affect tea quality on a spatiotemporal basis (Han et al., 2016).
2	Li, LK; Wang, MF; Pokharel, SS; Li, CX; Parajulee, MN; Chen, FJ; Fang, WP	Effects of elevated CO2 on foliar soluble nutrients and functional components of tea, and population dynamics of tea aphid, Toxoptera aurantii	2019	CO2	China	Li et al. (2019) showed that elevated CO2 significantly increased the foliar content of soluble sugars (+4.74%), theanine (+3.66%), and polyphenols (+12.01%) and reduced the foliar content of free amino acids (-9.09%) and caffeine (-3.38%) while the relative transcript levels of the genes of theanine synthetase (+18.64%), phenylalanine ammonia-lyase (+49.50%), s'-adenosine methionine synthetase (+143.03%) and chalcone synthase (+61.86%) were up-regulated, and that of caffeine synthase (-56.91%) was down-regulated for the tea seedlings grown under elevated CO2 relative to ambient CO2 (Li et al. 2019). Also, the foliar contents of jasmonic acid (+98.6%) and salicylic acid (+155.6%) increased for the tea seedlings grown under elevated CO2 compared to ambient CO2.
3	Ahmed, S; Griffin, TS; Kraner, D; Schaffner, MK; Sharma, D; Hazel, M; Leitch, AR; Orians, CM; Han, WY; Stepp, JR; Robbat, A; Matyas, C; Long, CL; Xue, DY; Houser, RF; Cash, SB	Environmental Factors Variably Impact Tea Secondary Metabolites in the Context of Climate Change	2019	CO2	World	Ahmed et al. (2019) stated a significant increase in concentrations of total polyphenols, catechins, and amino acids and C:N ratio with elevated CO2, while caffeine levels decrease (Li et al., 2017). Elevated CO2 changes the tea quality by influencing the concentrations and biosynthetic gene expression of tea polyphenols, free amino acids, catechins, theanine, and caffeine (Ahamed et al. 2020). Some molecules like salicylic acid and nitric oxide will signal to mediate the elevated CO2-by inducing defense compounds like flavonoid biosynthesis in tea leaves. (Ahamed et al. 2020). A 90 daysCO2 enrichment (750 mmol mol-1) results in 18.4, 22.0, and 20.1% increased chl a,b, & carotenoid (Jiang et al., 2005).
4	Li, X; Zhang, L; Ahammed, GJ; Li, ZX; Wei, JP; Shen, C; Yan, P; Zhang, LP; Han, WY	Stimulation in primary and secondary metabolism by elevated carbon dioxide alters green tea quality in Camellia sinensis L	2017	CO2	China	Li et al. (2016) showed that exposure of tea plants to elevated CO2 (800 μmol mol−1 for 24 d) remarkably improved both photosynthesis and respiration in tea leaves. Furthermore, elevated CO2 increased the concentrations of soluble sugar, starch, and total carbon but decreased the total nitrogen, resulting in an increased C:N ratio in tea leaves. Tea polyphenol, free amino acid, and theanine increased, while the caffeine concentration decreased after CO2 enrichment. The con. of individual catechins were altered differentially, resulting in increased total catechins under elevated CO2.
5	Jiang, Y., Zhang, S., & Zhang, Q.	Effects of elevated atmospheric CO2 concentration on photo-physiological characteristics of tea plant.	2005	CO2	China	The net photosynthesis increased under elevated (550 and 750μmol·mol-1) CO2. Midday depression of photosynthesis abated or disappeared. Stomatal conductance (Sc) reduced, and transpiration (Tr) decreased slightly. It was also found that chlorophyll a, chlorophyll b, total chlorophyll, and carotenoid contents increased under elevated CO2. The ratio of chlorophyll a to b was reduced. The N, K, and Ca contents in shoots decreased, and Mg, Fe, Zn, Mn, and Cu increased with CO2.
6	Xu, H., Li, L., Li, Q., Zhou, L., Zhu, X., Chen, F., ... & Fang, W.	Effects of elevated atmospheric CO2 concentration and temperature on photosynthesis system and quality components in tea plant.	2016	CO2	China	Both elevated CO2 and temperature had significant effects on photosynthetic parameters and chlorophyll fluorescence parameters in tea leaves compared with the control. Elevated [CO2] elevated temperature promoted the synthesis of chlorophyll a and chlorophyll b in tea leaves. Both elevated CO2 and temperature significantly increased the chlorophyll a and chlorophyll b contents in tea leaves. Elevated CO2 concentration, elevated temperature, and elevated CO2 and temperature significantly reduced the content of amino acids and caffeine in tea leaves while increasing the content of polyphenols and the ratio of polyphenols and amino acids.

7	Jiang, Y. L., Zhang, Q. G., & Zhang, S. D.	Effects of atmospheric CO2 concentration on tea quality.	2006	CO2	China	The amino acid contents in tea decreased by 1.7%~4.5% and 6.7%~12.2% under elevated (500 and 750 μmol/mol) CO2, compared to the ambient air [CO2]. At the same time, the caffeine contents were reduced by 3.1%~4.6% and 5.1%~10.7%. The polyphenol contents increased by 3.8%~6.0% and 6.9%~11.3%. The soluble saccharide contents increased by 8.4%~14.4% and 18.1%~28.2%. It was also found that the N, K, Ca, P, and Na contents in tea decreased, and Zn, Mg, and Fe contents increased with CO2 enrichment.
8	Li, X., Ahammed, G. J., Li, Z., Tang, M., Yan, P., & Han, W.	Decreased biosynthesis of jasmonic acid via lipoxygenase pathway compromised caffeine-induced resistance to Colletotrichum gloeosporioides under elevated CO2 in tea seedlings.	2016	CO2	China	The elevated CO2 reduced endogenous caffeine content in tea leaves and sharply increased tea's susceptibility to C. gloeosporioides. Increased JA biosynthesis via LOX pathway by caffeine might strengthen plant defense only under elevated CO2. In contrast, the caffeine-induced defense under ambient CO2 might be associated with the JA-independent LOX pathway in tea. These results provide novel insights into caffeine-induced plant defense mechanisms that might help develop an eco-friendly disease control approach.
9	Li, X., Zhang, L., Ahammed, G. J., Li, Z. X., Wei, J. P., Shen, C., ... & Han, W. Y.	Stimulation in primary and secondary metabolism by elevated carbon dioxide alters green tea quality in Camellia sinensis L.	2017	CO2	China	Exposure of tea plants to elevated CO2 (800 μmol mol−1 for 24 d) improved both photosynthesis and tea leaves' respiration. Elevated CO2 increased the concentrations of soluble sugar, starch, and total carbon but decreased the total nitrogen concentration, resulting in an increased carbon to nitrogen ratio in tea leaves. Among the tea quality parameters, tea polyphenol, free amino acid, and theanine concentrations increased, while the caffeine concentration decreased after CO2 enrichment. The concentrations of individual catechins were altered differentially, resulting in an increased total catechins concentration under elevated CO2 conditions.
10	Coll, M., & Hughes, L.	Effects of elevated CO2 on an insect omnivore: a test for nutritional effects mediated by host plants and prey.	2008	CO2	China	Tea grown at elevated CO2 were significantly larger, with reduced N content than plants grown at ambient CO2. H. armigera larvae feeding on elevated CO2-grown plants were significantly smaller than those grown on ambient-grown plants, but prey N content did not differ between CO2 treatments.
11	Kazan, K.	Plant-biotic interactions under elevated CO2: A molecular perspective	2018	CO2	World	eCO2 alters phytohormone and reactive oxygen signaling, secondary metabolism, and defense-associated development such as stomatal responses in the host. eCO2 can also directly and/or indirectly influence pathogenesis- and herbivory-related traits in pest and pathogen populations. eCO2 alters predator-prey interactions by interfering with indirect defenses and chemical communications in pests.
12	Li X., Zhang L., Ahammed G.J., Li Y.-T., Wei J.-P., Yan P., Zhang L.-P., Han X., Han W.-Y.	Salicylic acid acts upstream of nitric oxide in elevated carbon dioxide-induced flavonoid biosynthesis in tea plant (Camellia sinensis L.)	2019	CO2	China	Flavonoids, salicylic acid (SA), and Nitric oxide (NO) levels increased in tea plants in elevated CO2 levels (550 and 800 mol mol^{-1}).
13	Li X., Ahammed G.J., Zhang L., Yan P., Zhang L., Han W.-Y.	Elevated carbon dioxide-induced perturbations in metabolism of tea plants	2018	CO2	China	Elevated CO2 increases total carbon concentration and decrease total nitrogen concentration while improving tea quality by increasing tea polyphenol, free amino acid, including theanine contents, and decreasing caffeine (Li et al. 2018).
14	Huang, H; Kfoury, N; Orian, CM; Griffin, T; Ahmed, S; Cash, SB; Stepp, JR; Xue, DY; Long, CL; Robbat, A	2014-2016 seasonal rainfall effects on metals in tea (Camelia sinensis (L.) Kuntze)	2019	Season	China	Metal nutrient concentrations in tea varied in response to climate changes. Huang et al. (2018) assessed the macro-and micronutrient metal concentrations in pre-monsoon (spring), monsoon (summer), and post-monsoon (autumn) tea from Yunnan Province, China from 2014 to 2016. Fe, Ca, Mg, Mn, Al, and Ba concentrations were higher in June (monsoon) than in March (pre-monsoon) and September (post-monsoon) compared to Pb, K, Cu, Zn, and Na, which were higher in March and September. Although Fe, Ca, Mg, Mn, Al, and Ba concentrations increased during the monsoon season. ü Striking changes occur in secondary metabolite chemistry when the plant experiences heavy rainfall (Ahmed et al., 2014; Kowalsick et al., 2014). Huang et al. (2018) found that catechin concentrations decreased five days after the East Asian Monsoon rains (Ahmed et al., 2014). Although catechins are polyphenols, the concentration of total phenolics increased dramatically

15	Kfoury, N; Baydakov, E; Gankin, Y; Robbat, A	Differentiation of key biomarkers in tea infusions using a target/nontarget gas chromatography/mass spectrometry workflow	2018	Season	China	Kfoury et al. (2018) showed that the seasonal changes in climate impact tea plants similarly despite location differences. For example, spring teas contained more of the sweet, floral, and fruity compounds compared to summer teas, which had higher concentrations of green, woody, herbal compounds.
16	Boehm, R; Cash, SB; Anderson, BT; Ahmed, S; Griffin, TS; Robbat, A; Stepp, JR; Han, W; Hazel, M; Orians, CM	Association between Empirically Estimated Monsoon Dynamics and Other Weather Factors and Historical Tea Yields in China: Results from a Yield Response Model	2016	Season	China	Boehm et al. (2015) found that a 1% increase in the monsoon retreat date is associated with a 0.481%–0.535% reduction in tea yield while a 1% increase in the date of the monsoon retreat with a 0.604% decrease in tea yields. For precipitation, they found that a 1% increase in daily precipitation occurring during the monsoon period is associated with a 0.184%–0.262% reduction in tea yields and 1% increase in the average daily monsoon precipitation from the previous growing season is associated with 0.258%–0.327% decline in yields. They also find that a 1% decrease in solar radiation in the previous growing season is associated with a 0.554%-0.864% decrease in tea yields.
17	Ahmed, S; Stepp, JR; Orians, C; Griffin, T; Matyas, C; Robbat, A; Cash, S; Xue, DY; Long, CL; Unachukwu, U; Buckley, S; Small, D; Kennelly, E	Effects of Extreme Climate Events on Tea (Camellia sinensis) Functional Quality Validate Indigenous Farmer Knowledge and Sensory Preferences in Tropical China	2014	Season	China	Ahmed et al. (2014) compared to the spring drought, tea growth during the monsoon period was up to 50% higher. Concurrently, concentrations of catechin and methylxanthine secondary metabolites, major compounds that determine tea functional quality, were up to 50% lower during the monsoon while total phenolic concentrations and antioxidant activity increased. The inverse relationship between tea growth and concentrations of individual secondary metabolites suggests a dilution effect of precipitation on tea quality.
18	Xu, W., Song, Q., Li, D., & Wan, X.	Discrimination of the production season of Chinese green tea by chemical analysis in combination with supervised pattern recognition	2012	Season	China	Levels of free amino acids and catechins in green tea leaves show obvious variation from spring to summer, useful information to identify the production season of commercial green tea.
19	Bhandari, K; De, B; Goswami, TK	Evidence based seasonal variances in catechin and caffeine content of tea	2019	Season	India	HPLC analysis shows concentrations of catechin and caffeine content in tea leaves decrease in monsoon and a further decrease in autumn (Bhandari et al. 2019).
20	Han, WY; Shi, YZ; Ma, LF; Ruan, JY; Zhao, FJ	Effect of liming and seasonal variation on lead concentration of tea plant	2007	Season	China	The study conducted by Han et al. (2007) revealed that seasonal variation might affect Pb concentrations in the new tea shoots as per the order of spring > autumn > summer, and climate change may influence to exceed the maximum possible thresholds of Pb concentration (2 mg kg-1) in China in the future.
21	Yao, L., Caffin, N., D'arcy, B., Jiang, Y., Shi, J., Singanusong, R., ... & Xu, Y.	Seasonal variations of phenolic compounds in Australia-grown tea (Camellia sinensis)	2005	Season	Australia	In the warmer months, the levels of EGCG, ECG, and CGs were in most cases significantly higher ($P < 0.05$) than those in the samples harvested in the cooler months.
22	Hajiboland, R	Environmental and nutritional requirements for tea cultivation	2017	Season and CO2	Review: World context	It is also predicted that global climate change will have a considerable adverse impact on tea production in the future (Hajiboland, 2019). A report on climate change in Asia predicts a 10% extension of the dry and wet seasons in the main tea plantation area by 2070, together with an increased frequency and severity of extreme weather events. Temperature increases of 0.4 to 3.0°C are also predicted, while rainfall is expected to increase with an uneven distribution pattern (FAO 2016). Several other climate change-induced variables have been identified and used in simulation models to predict climate change impacts on tea yield at different altitudes (Wijeratne et al. 2007a). The predicted tea yields by the year 2050 under the climate change scenarios specified by these models showed increased yields at higher altitudes but reduced yields at lower altitudes (de Costa et al. 2007).
23	Ahmed, S., Peters, C. M., Chunlin, L., Meyer,	Biodiversity and phytochemical quality in indigenous and state-	2013	Season, Geography, Drought	China	They found higher water availability for tea crop drive to increase total methylxanthine and phenolic concentrations while decreasing Epigallocatechin gallate concentrations.

	R., Unachukwu, U., Litt, A., ... & Stepp, J. R.	supported tea management systems of Yunnan, China.				
24	Kaur L., Donlao N.	Tea antioxidants as affected by environmental factors	2018	Season and Geography	China	Kaur and Donlao (2018) indicated that both season and geographical locations are important to produce tea with higher polyphenol and antioxidants content.
25	Kfoury, N; Scott, ER; Orians, CM; Ahmed, S; Cash, SB; Griffin, T; Matyas, C; Stepp, JR; Han, WY; Xue, DY; Long, CL; Robbat, A	Plant-Climate Interaction Effects: Changes in the Relative Distribution and Concentration of the Volatile Tea Leaf Metabolome in 2014-2016	2019	Season and Elevation	China	Kfoury et al. (2019) detected 564 metabolites from tea grown at two elevations in spring and summer over 3 years in two major tea-producing areas of China. Kfoury et al. (2019) showed elevation and seasonal differences were strongly influenced by tea's secondary metabolites.
26	Li, X; Wei, JP; Ahammed, GJ; Zhang, L; Li, Y; Yan, P; Zhang, LP; Han, WY	Brassinosteroids Attenuate Moderate High Temperature-Caused Decline in Tea Quality by Enhancing Theanine Biosynthesis in tea	2018	Season and Temperature	China	Li et al. (2018) showed that high temperature (35 ˚C) gradually decreased theanine concentration in tea leaves. Seasonal studies show that tea is grown in a warmer climate (e.g., summer tea) is bitter, which is well correlated to high polyphenol and low theanine contents (Xu et al., 2012). High temperatures negatively impact theanine content in tea (Liu et al., 2017b).
27	Wang, LY; Wei, K; Jiang, YW; Cheng, H; Zhou, J; He, W; Zhang, CC	Seasonal climate effects on flavanols and purine alkaloids of tea (Camellia sinensis L.)	2011	Season and Temperature	China	Wang et al. (2011) showed (-)-epigallocatechin (EGC), (-)-epicatechin (EC), (-)-epicatechin gallate (ECG) and (-) epigallocatechin gallate (EGCG) increased, but (+)-catechin (C) decreased with increasing daily average temperature (DAT). A long period of precipitation (PRE) led to the declines of EGC, EC, ECG, EGCG, and their total content (TC) but increased C content. Furthermore, relative humidity (RH) significantly affected EGC, TC, and caffeine.
28	Kfoury, N; Morimoto, J; Kern, A; Scott, ER; Orians, CM; Ahmed, S; Griffin, T; Cash, SB; Stepp, JR; Xue, DY; Long, CL; Robbat, A	Striking changes in tea metabolites due to elevational effects	2018	Elevation and Temperature	China	Ahmed, Stepp, Orians, Griffin, Matyas, Robbat Jr, et al., 2014) measured a 50% decrease in the concentration of catechins in tea harvested from Yunnan Province, China the spring to summer transition (low to monsoon rainfalls). ü In contrast, total polyphenol content and antioxidant potential were much higher, meaning other phenolic compounds such as flavones, flavonols, phenolic acids, and their derivatives (Kalili & de Villiers, 2010) increased in concentration as catechins decreased. ü Differences in the composition of volatile secondary metabolites were found. Many increased, others decreased by hundreds of percent, while some exhibited no change in concentration (Kowalsick, Kfoury, Robbat Jr, Ahmed, Orians, Griffin, et al., 2014). ü Some researchers report higher concentrations in high altitude tea, whereas others measured higher concentrations in low elevation ü Farmers associate aromatic quality with higher elevation teas (Ahmed & Stepp, 2012)
29	Han, WY; Huang, JG; Li, X; Li, ZX; Ahammed, GJ; Yan, P; Stepp, JR	Altitudinal effects on the quality of green tea in east China: a climate change perspective	2017	Elevation and Temperature	China	Han et al. (2016) showed that an increase in cultivation altitude decreased total tea polyphenols (TP) but increased amino acids (AA) concentration, decrease in TP/AA, one of the most important parameters that determine the taste of green tea. The constituents of AA, especially theanine, glutamic acid, arginine, serine, γ-aminobutyric acid, and aspartic acid, increased with increasing elevation gradients. Nonetheless, the constituents of polyphenolic compounds, especially individual catechins, were differentially altered with the change in cultivation altitude. With increasing elevation, the epigallocatechin-3-gallate and epicatechin gallate decreased, while the epigallocatechin and gallocatechin gallate increased eventually caused no significant variation in the total catechins in different sites. Additionally, the percentage of catechins to TP was increased with increasing altitude. Rising temperatures, particularly at a lower altitude, perhaps, will deteriorate tea quality. Increasing temperatures will negatively affect tea yields, particularly in the tropical and subtropical regions (Ahmed et al. 2014)

30	Lee, JE; Lee, BJ; Chung, JO; Kim, HN; Kim, EH; Jung, S; Lee, H; Lee, SJ; Hong, YS	Metabolomic unveiling of a diverse range of green tea (Camellia sinensis) metabolites dependent on geography	2015	Temperature, rainfall, and daylight exposure	China	Temperature, rainfall, and daylight exposure were affected on tea metabolites (Lee et al., 2010 & 2015).
31	Lee, JE; Lee, BJ; Chung, JO; Hwang, JA; Lee, SJ; Lee, CH; Hong, YS	Geographical and Climatic Dependencies of Green Tea (Camellia sinensis) Metabolites: 32A H-1 NMR-Based Metabolomics Study	2010	Temperature and Rainfall	China	Lee et al. (2010) investigated that green teas grown in an area with high temperature, long sun exposure time, and high rainfall had higher levels of theanine but lower levels of isoleucine, leucine, valine, alanine, EC, EGC, EGCG, and caffeine than those grown in areas with relatively low temperature, short sun exposure time, and low rainfall. These results indicate that high temperature, long sun exposure, and high precipitation stimulate theanine synthesis in green tea during the spring season.
32	Zhang, CY; Yi, XQ; Zhou, F; Gao, XZ; Wang, MH; Chen, JJ; Huang, JN; Shen, CW	Comprehensive transcriptome profiling of tea leaves in response to simulated acid rain	2020	Rainfall	China	Acid rain is another factor caused by climate change. The study conducted by Zhang et al. (2020) demonstrated that tea plants affected by simulated acid rain (SAR) at 2.5 produce metabolic disorders and indicate warnings to maintain the quality of tea in south China in the future.
33	Ahmed, S; Orians, CM; Griffin, TS; Buckley, S; Unachukwu, U; Stratton AE; Stepp, JR; Robbat, .. S; Kennelly, EJ	Effects of water availability and pest pressures on tea (Camellia sinensis) growth and functional quality	2014	Water Deficit	China	Extreme shifts in water availability linked to global climate change (Ahmed et al. 2014)
33	Upadhyaya, H., Dutta, B. K., & Panda, S. K.	Zinc modulates drought-induced biochemical damages in tea [Camellia sinensis (L) O Kuntze].	2013	Drought	India	The drought-induced decrease in relative water content (RWC), dry mass of leaf, antioxidants, and increased phenolic content reduced hydrogen peroxide (H2O2) and lipid peroxidation, enzymes, and Zn modulate drought-mediated damages in the tea plant.
35	Upadhyaya, H., Panda, S. K., & Dutta, B.	CaCl 2 improves post-drought recovery potential in Camellia sinensis (L) O. Kuntze.	2011	Drought	India	This study investigates the effect of CaCl2 on the antioxidative responses of tea during post-drought recovery. An increase in dry mass, proline, and phenolic content of leaf with a decrease in H2O2 and lipid peroxidation and increased activities of enzymes in response to increased foliar CaCl2 concentration are indications for the recovery of stress-induced oxidative damage.
36	Cheruiyot, E. K., Mumera, L. M., NG'ETICH, W. K., Hassanali, A., & Wachira, F.	Polyphenols as potential indicators for drought tolerance in tea (Camellia sinensis L.).	2007	Drought	Kenya	The declining soil water content (SWC) reduced both the growth and content of polyphenols in tea. Tolerant clones maintained a high polyphenol content at low SWC and showed less fluctuation in phenolics when subjected to changes in SWC. There is a potential to use polyphenols as indicators for the selection of drought-tolerant tea cultivars.
37	Cheruiyot, E. K., Mumera, L. M., NG'ETICH, W. K., Hassanali, A., Wachira, F., & Wanyoko, J. K.	Shoot epicatechin and epigallocatechin contents respond to water stress in tea [Camellia sinensis (L.) O. Kuntze].	2008	Drought	Kenya	The total catechins showed a significant correlation with shoot growth, soil water content, and water stress index. The epicatechin (EC) correlated with shoot growth, soil water content, and water stress index. Similarly, epigallocatechin (EGC) correlated with shoot growth (r=0.65, P=0.0006), soil water content, and water stress index. However, epigallocatechin gallate (EGCg) and epicatechin gallate (ECG) showed no significant response to changes in SWC. EC and EGCcan use as indicators in predicting drought tolerance in tea.
38	Chakraborty, U., Dutta, S., & Chakraborty, B. N.	Response of tea plants to water stress.	2002	Drought	Kenya	Phenol content and activities of phenylalanine ammonialyase, polyphenol oxidase, and peroxidase initially increased but decreased during an extended drought. Chlorophyll contents decreased, whereas proline contents increased during water stress.
39	Cao, P., Liu, C., & Liu, K.	Aromatic constituents in fresh leaves of Lingtou Dancong tea induced by drought stress.	2007	Drought	China	The total amount of relative contents of 17 kinds of aromatic components such as linalool etc., increased with drought stress, whereas 12 kinds of aromatic components, such as tetradecanoic acid etc., decreased with drought stress. Different degrees of drought stress could induce various aromatic types of constituents, and the number of aromatic constituents induced with the strengthening of drought stress.
40	Scott, ER; Li, X; Kfoury, N; Morimoto, J; Han, WY; Ahmed, S; Cash,	Interactive effects of drought severity and simulated herbivory on tea (Camellia sinensis)	2019	Drought	USA	Severe drought generally inhibits the induction of secondary metabolites, including methyl salicylate (Scott et al. 2019).

	SB…Stepp, JR; Robbat, A; Orians, CM	volatile and non-volatile metabolites				
41	Nalina, M; Saroja, S; Rajkumar, R; Radhakrishnan, B; Chandrashekara, KN	Variations in quality constituents of green tea leaves in response to drought stress under south Indian condition	2018	Drought	India	The decline of rainfall due to climate change causes soil moisture deficit in tea fields, and it influences the variation of the biochemical present in tea leaves. Nalina et al. (2019) showed that drought tolerant tea varieties accumulate higher levels of biochemical during the soil water stress conditions.
42	Wang, Y; Fan, K; Wang, J; Ding, ZT; Wang, H; Bi, CH; Zhang, YW; Sun, HW	Proteomic analysis of Camellia sinensis (L.) reveals a synergistic network in the response to drought stress and recovery	2017	Drought	China	Wang et al. (2017) indicated that slight drought stress promoted polyphenol biosynthesis, while serious drought stress leads to inhibition.
43	Wang, WD; Xin, HH; Wang, ML; Ma, QP; Wang, L; Kaleri, NA; Wang, YH; Li, XH	Transcriptomic Analysis Reveals the Molecular Mechanisms of Drought-Stress-Induced Decreases in tea Leaf Quality	2016	Drought	China	Wang et al. (2016) indicated that drought stress significantly reduces the total polyphenols and free amino acids and increases the total flavonoids. Also, the catechins, caffeine, theanine, and some free amino acids in C. sinensis leaves were significantly reduced in response to drought stress, implying that drought stress severely decreased the quality of C. sinensis leaves.
44	Zhou, L; Xu, H; Mischke, S; Meinhardt, LW; Zhang, DP; Zhu, XJ; Li, XH; Fang, WP	Exogenous abscisic acid significantly affects proteome in tea plant (C. sinensis) exposed to drought stress	2014	Drought	China	Understanding of ABA effects on tea plant under drought stress is essential to develop drought-tolerant tea genotypes (Zhou et al. 2014)
45	Chaeikar, SS; Marzvan, S; Khiavi, SJ; Rahimi, M	Changes in growth, biochemical, and chemical characteristics and alteration of the antioxidant defense system in the leaves of tea clones (Camellia sinensis L.) under drought stress	2020	Drought	Iran	Drought stress brings detrimental impacts on biochemical profile in field-grown tea, including a decline in total polyphenol and total ash content while increase proline and total sugar as per the study conducted by Chaeikar et al. (2020).
46	Zhang, XC; Wu, HH; Chen, JG; Chen, LM; Wan, XC	Chloride and amino acids are associated with K+-alleviated drought stress in tea	2020	Drought	China	Some studies have reported that water content and chlorophyll are higher in plants exposed to drought stress, and K+ supplements alleviate drought stress with the components of chloride and amino acids (Zhang et al. 2020).
47	Li, HJ; Wang, HB; Chen, Y; Ma, QP; Zhao, Z; Li, XH; Chen, X	Isolation and expression profiles of class III PRX gene family under drought stress in tea	2020	Drought	China	According to the experiment conducted by Li et al. (2020), abscisic acid (ABA) and methyl jasmonate (MeJA) protect tea plants from drought stress.
48	Cheruiyot E.K., Mumera, Ng'etich W.K., Hassanali A, Wachira F.	Polyphenols as potential indicators for drought tolerance in tea (Camellia sinensis L.)	2007	Drought	Kenya	Cheruiyot et al. (2007) indicated that declining soil water content (SWC) reduced both the growth and content of polyphenols in tea. Tolerant clones maintained a high polyphenol content at low SWC and less fluctuation in phenolics when subjected to changes in SWC.
49	Zhang, Q., Shi, Y., Ma, L., Yi, X., & Ruan, J	Metabolomic analysis using ultra-performance liquid chromatography-quadrupole-time of flight mass spectrometry uncovers the effects of light intensity and temperature under shading treatments on the metabolites in tea	2014	Solar Radiation	China	Most flavonoid metabolites (mainly flavan-3-ols, flavonols, and their glycosides) decreased significantly in the shading treatments, while the contents of chlorophyll, β-carotene, neoxanthin, and free amino acids, caffeine, benzoic acid derivatives, and phenylpropanoids increased. A greater effect of temperature on galloylation of catechins than light intensity.

50	Zheng, X. Q., Jin, J., Chen, H., Du, Y. Y., Ye, J. H., Lu, J. L., ... & Liang, Y. R.	Effect of ultraviolet B irradiation on accumulation of catechins in tea (Camellia sinensis (L) O. Kuntze	2008	Solar Radiation	China	Low influence rate and short-term irradiation of UV-B stimulated accumulation of major tea catechins, resulting in an increase in the level of total catechins. Excessive irradiation of UV-B suppressed the accumulation of tea catechins. Epigallocatechin gallate (EGCG) increased more quickly than the other catechins under appropriate UV-B irradiation.
51	Li, YC; Jeyaraj, A; Yu, HP; Wang, Y; Ma, QP; Chen, X; Sun, HW; Zhang, H; Ding, ZT; Li, XH	Metabolic Regulation Profiling of Carbon and Nitrogen in Tea Plants [C. sinensis (L.) O. Kuntze] in Response to Shading	2020	Sunlight/Radiation	China	Li et al (2020) showed that flavonoids metabolism, carbon, and nitrogen metabolism are affected by short-term shading, while the glycolytic pathway and the trcarboxylic acid cycle (TCA cycle) are inhibited by long-term shading, indicating the importance of light management in tea fields.
52	Lu, ZW; Liu, YJ; Zhao, L; Jiang, XL; Li, MZ; Wang, YS; Xu, YJ; Gao, LP; Xia, T	Effect of low-intensity white light mediated de-etiolation on the biosynthesis of polyphenols in tea seedlings	2014	Sunlight/Radiation	China	Some studies resulted in inconsistent accumulation patterns of phenolic acids, flavan-3-ols, and flavonols in tea seedlings in the presence of sunlight (Lu et al. 2014). In addition, the accumulation of catechins was possibly jointly influenced by the biosynthesis, hydrolysis, glycosylation, and galloylation of polyphenols in tea plants.
53	Sano S., Takemoto T., Ogihara A., Suzuki K., Masumura T., Satoh S., Takano K., Mimura Y., Morita S.	Stress responses of shade-treated tea leaves to high light exposure after removal of shading	2020	Sunlight/Radiation	Japan	Sano et al. (2020) studied the impact of different shade-levels (i.e., shaded, high light-HL, and non-shaded control) on tea plants and identified that Chlorophyll a/b ratio was higher in HL treated plants than in shaded plants. The enzymes and antioxidant activities, total ascorbate level, and ascorbate/dehydroascorbate ratio were decreased and increased in response to low light and highlight (HL) levels.
54	Zeng, LT; Watanabe, N; Yang, ZY	Understanding the biosynthesis and stress response mechanisms of aroma compounds in tea (C. sinensis) to safely and effectively improve tea aroma	2019	All stressors	China	Zeng et al. (2019) indicated the importance of understanding the association between tea aroma components and stresses (i.e., biotic and abiotic). These stresses will govern the expression of aroma synthetic genes in tea leaves.
55	Mozumder, NHMR; Lee, YR; Hwang, KH; Lee, MS; Kim, EH; Hong, YS	Characterization of tea leaf metabolites dependent on tea plant age through H-1 NMR-based metabolomics	2020	All stressors	Korea	The chemical or metabolic compositions of tea (Camellia sinensis) vary according to numerous factors, including climate (Mozumder et al. 2020).
56	Zhou W., Liu R., Jiang D., Guo H.	Climate Change and Impact Assessment for the Quality of Guzhang Maojian Tea	2019	All stressors	Guzhang Maojian - China	Zhou et al. (2019) indicated that the key disastrous climate factors affecting Guzhang Maojian tea production are high temperature, heat damage, frost, and they further observed that Spring tea quality was high than autumn tea and that summer tea comes next.
57	Wei K., Wang L., Zhou J., He W., Zeng J., Jiang Y., Cheng H.	Catechin contents in tea (Camellia sinensis) as affected by cultivar and environment and their relation to chlorophyll contents	2011	All stressors	China	Wei et al. (2011) indicated that (+)-catechin was the major catechin fraction significantly correlated with climate factors and chlorophyll contents. Moreover, chlorophyll contents were significantly influenced by climate factors, with the highest correlation coefficient for daily lowest temperature.

Table S6. Impacts of current and future climate on climate suitability for tea

No.	Authors	Article Title	Year	Country	Key Findings
1	Jayasinghe, SL; Kumar, L; Hasan, MK	Relationship between Environmental Covariates and Ceylon Tea Cultivation in Sri Lanka	2020	Sri Lanka	Jayasinghe et al, (2020) found that when the annual mean temperature increased, the suitability of tea cultivation decreased, but an increased rainfall had increased the suitability of an area for tea cultivation. It is proposed that the results of this study could be utilized in the assessment of the climate or/and land suitability for tea.
2	Rivera-Parra, JL; Pena-Loyola, PJ	Potential high-quality growing tea regions in Ecuador: an alternative cash crop for Ecuadorian small landholders	2020	Ecuador	Rivera-Parra and Peña-Loyola (2020) used a GIS-based analysis, together with ecological niche modeling, to determine areas in Ecuador where Ceylon and Nilgiris tea varieties could be grown and found that there is more than 150 000 ha in Ecuador that could be converted to high-quality tea plantations, most of them in the coastal provinces, with some specific areas in the Andean foothills, with no significant ecological niche modifications due to climate change in the long-term future.
3	Kotikot, SM; Flores, A; Griffin, RE; Nyaga, J; Case, JL; Mugo, R; Sedah, A; Adams, E; Limaye, A; Irwin, DE	Statistical characterization of frost zones: Case of tea freeze damage in the Kenyan highlands	2020	Kenya	Kotikot et al. (2020) attempted to delineate frost zones by statistically characterizing them based on known risk factors related to topography in the Kenyan tea growing area. The agency estimates that up to a third of the tea bushes within Nandi Hills, a key tea-producing region, are affected by extreme weather conditions, including hail and frost (Kotikot et al. 2020).
4	Deng, SR; Lou, WP; Zhao, YM; Sun, K; Chen, KC	Evaluation and spatial distribution of tea plant heat injury risk	2020	China	Deng et al. (2019) suggested that the risk of tea plant heat injury (RTHI) increases with climate warming; therefore, it is necessary to consider local geographical factors and select suitable tea plant planting and management techniques to reduce the impact of heatwaves on tea production. High values of RTHI were found in central Zhejiang province. RTHI values decreased with altitude in mountainous areas, with values of 0 at altitudes above 530 m. Because of low altitude and surrounding mountains preventing hot air from circulating between the inside of basin areas and outside, RTHI values were high in the middle of basins. Frost events and freezing cause injury to tea plants (Huang 1989; Lou and Sun 2013; Lou et al. 2015). Heat injury of the tea plant is caused by heatwaves, which are one of the extreme weather events (IPCC 2014).
5	Jayasinghe, SL; Kumar, L	Modeling the climate suitability of tea [Camellia sinensis(L.) O. Kuntze] in Sri Lanka in response to current and future climate change scenarios	2019	Sri Lanka	Jayasinghe et al. (2019) showed that most of the optimal and medium suitability areas in the low elevation areas in Sri Lanka would be lost to a greater extent compared to the high elevation areas for all tested RCPs by 2050 and 2070 under both GCMs of MIROC5 and CCSM4. The comparison of the current and future distributions of suitable tea growing areas revealed a decline of approximately 10.5%, 17%, and 8% in total 'optimal', 'medium', and 'marginal' suitability areas, respectively, implying that climate would have a negative effect on the habitat suitability of tea in Sri Lanka by 2050 and 2070.
6	Jayasinghe, SL; Kumar, L; Sandamali, J	Assessment of Potential Land Suitability for Tea (Camellia sinensis (L.) O. Kuntze) in Sri Lanka Using a GIS-Based Multi-Criteria Approach	2019	Sri Lanka	Jayasinghe et al. (2019) assessed land suitability to determine suitable agricultural land for tea crops in Sri Lanka. The results showed that the largest part of Sri Lanka's land was occupied by the low suitability class (42.1%), and 28.5% registered an unsuitable land cover. Furthermore, 12.4% was moderately suitable, 13.9% was highly suitable, and 2.5% was very highly suitable for tea cultivation. The highest proportion of “very highly suitable” areas were recorded in the Nuwara Eliya District, which accounted for 29.50% of the highest category.
7	Ngoc, HTH; Van, TTT; Ha, NM; Binh, NQ; Tan, MT	Bioclimatic assessments for tea cultivation in Western Nghe An	2019	Vietnam	Based on the tea plant's bioclimatic characteristics and regional climate data from 1980 to 2014, the bioclimatic diagrams are built, and the tea cultivability is mapped in terms of annual average and total precipitation. Also, Ngoc et al. (2019) found that both temperature and precipitation in Con Cuong, Vietnam is relatively suitable for the tea plantation.
8	Ranjitkar, S; Sujakhu, NM; Lu, Y; Wang, Q; Wang, MC; He, J; Mortimer, PE; Xu, JC; Kindt, R; Zomer, RJ	Climate modelling for agroforestry species selection in Yunnan Province, China	2016	China	Ranjitkar et al. (2015) used a multi-model ensemble approach based on ecological niche modeling was used to understand the impact of climate on the distribution of agroforestry trees, including tea.
9	Adhikari, U; Nejadhashemi, AP; Woznicki, SA	Climate change and eastern Africa: a review of impact on major crops	2015	Africa	Adhikari et al. (2015) investigated that the optimum production zones for tea and coffee, major cash crops in the region, are projected to shift towards higher elevations. Thus current production zones are projected to see a decline in production.

10	Jayathilaka, PMS; Soni, P; Perret, SR; Jayasuriya, HPW; Salokhe, VM	Spatial assessment of climate change effects on crop suitability for major plantation crops in Sri Lanka	2012	Sri Lanka	Jayathilaka et al. (2011) examined the geographic shift of suitability, yield, and tea climate classes. They found a long-term annual rainfall significantly decreased in the mid-country wet zone, whereas the study area's mean temperature increased by 1.4 ˚C. Results clearly showed that the climate and yield could be meaningfully related to the tea suitability and management.
11	Li, B; Zhang, F; Zhang, LW; Huang, JF; Jin, ZF; Gupta, DK	Comprehensive Suitability Evaluation of Tea Crops Using GIS and a Modified Land Ecological Suitability Evaluation Model	2012	China	Bo et al. (2012) evaluated the suitability of tea crops in Zhejiang Province, the annual mean temperature, the annual accumulated temperature above 10 ˚C, the frequency of extremely low temperature below −13˚C, the mean humidity from April to October, slope, aspect, altitude, soil type, and soil texture were selected from climate, topography, and soil factors as factors for land ecological evaluation. The results demonstrated that the highly, moderately, and non-suitable regions for the cultivation of tea crops in Zhejiang Province were 27 552.66, 42 724.64, and 26 507.97 km2, and accounted for 28.47%, 44.14%, and 27.39% of the total area, respectively.
12	Chang, K., & Brattlof, M.	Contribution of tea production and exports to food security, rural development and smallholder welfare in selected producing countries.	2015	Tea producing countries - Common	If temperatures become too high or/and undesirable rainfall distribution for tea cultivation in a given area, newly suitable land areas need to be found.
13	Reay, D.	Climate-smart food	2019	Tea producing countries - Common	They found that moving cultivation to new areas is likely to be the only option in some areas as the climate envelop for tea shifts further in the coming decades.
14	Rigden, AJ Ongoma, Victor Huybers, Peter	Kenyan tea is made with heat and water: how will climate change influence its yield?	2020	Kenya	There is limited suitable land that would allow for adapting Kenyan tea production to a changing climate by moving farms to higher elevation due to the changes in temperature and soil moisture in the Kenyan highlands
15	Laderach, P., & Eitzinger, A.	Report of Future climate scenarios for Kenya tea growing areas CIAT.	2011	Kenya	The optimum tea-producing zone is currently at an altitude of 1,500–2,100 meters above sea level (masl) and, by 2050, will increase to an altitude of 2,000–2,300 masl. Increasing altitude compensates for the increase in temperature, and by 2050 areas at altitudes of 1,400–2,000 masl will suffer the highest decrease in suitability and the areas around 2,300 masl the highest increase in suitability
16	Eitzinger, A., Läderach, P., Quiroga, A., Pantoja, A., & Gordon, J.	Future climate scenarios for Uganda's tea growing areas.	2011	Uganda	The optimum tea- growing areas in Uganda are projected to shift from the current 1450–1650 meter above sea level to 1550–1650 meter above sea level under the A2 storyline
17	Bhagat, R. M., Ahmed, K. Z., Gupta, N., Baruah, R. D., Wijeratne, M. A., Bore, J. K., & Ahammed, G. J.	Report of the working group on climate change of the FAO intergovernmental group on tea	2016	India	Climate change which has become more severe in recent years, is already being witnessed in many tea-growing countries of the world, including India. Climate would have a negative effect on the habitat suitability of tea in India. For example, every year, the river Brahmaputra inundates a large area in its floodplain, which creates a waterlogging condition in the productive tea growing areas in North East India.
18	Dutta, R.	Monitoring green leaf tea quality parameters of different TV clones grown in northeast India using satellite data.	2013	India	Dutta (2013) predicted that some current tea-growing areas in Northeast India might become unsuitable for tea by 2050. There may be the suitability of the new regions for tea growing where tea has never been grown before. They also predicted climate variation in 2050 using DIVA-GIS Model, and it shows that the overall climate will become less seasonal in terms of variation through the years as the temperature in some districts is likely to increase by about 2ºC by 2050, followed by variations in monthly precipitation during the peak production months.
19	Kim, Y. K., Jombart, L., Valentin, D., & Kim, K. O.	Familiarity and liking playing a role on the perception of trained panelists: A cross-cultural study on teas	2015	Korea	Kim et al. (2015) investigated that C. japonica, currently located along the southern coastline in the southern part of the Korean Peninsula, is predicted to gradually disappear by 2070 under the HadGEM-AO model.

20	Koo, K. A., Park, S. U., Hong, S., Jang, I., & Seo, C.	Future distributions of warm-adapted evergreen trees, Neolitsea sericea and Camellia japonica under climate change: ensemble forecasts and predictive uncertainty	2018	Korea	Ah Koo et al. (2017) predicted future distributions of Camellia japonica L., under climate change in the Korean Peninsula (KP) showed both inland and northward expansions under 20 climate change scenarios in the future. But the highly suitable habitats of C. japonica will decline or shift to the north under climate change, especially in coastal areas due to sea-level rise, and may restrict their continuous range expansions under further climate changes
21	Sombroek, W. G., & Gommes, R.	The climate change-agriculture conundrum.	1996	Tea producing countries - Common	Increased rainfall in the humid area may impair adequate crop drying and result in increased runoff and erosion with a higher frequency of floods which can be intensified and reduce climate suitability for tea
22	Nakao, K., Higa, M., Tsuyama, I., Lin, C. T., Sun, S. T., Lin, J. R., ... & Tanaka, N.	Changes in the potential habitats of 10 dominant evergreen broad-leaved tree species in the Taiwan-Japan archipelago.	2014	Taiwan	They predicted potential habitats of Camellia japonica in Taiwan is predicted to decrease within the range of 32.4–42.3 by 2081-2100, suggesting suitable areas will be vulnerable at the southern range limits
23	Bo, L. I., Zhang, F., ZHANG, L. W., HUANG, J. F., Zhi-Feng, J. I. N., & Gupta, D. K.	Comprehensive suitability evaluation of tea crops using GIS and a modified land ecological suitability evaluation model.	2012	China	Based on the land-use map of Zhejiang Province, the regions that were completely unsuitable for tea cultivation in the province were eliminated, and then the spatial distribution of the ecological suitability of tea crops was generated using the modified LESE model and GIS. The results demonstrated that the highly, moderately, and non-suitable regions for the cultivation of tea crops in Zhejiang Province were 27 552.66, 42 724.64, and 26 507.97 km2, and accounted for 28.47%, 44.14%, and 27.39% of the total evaluation area, respectively
24	Wickramagamage, P	Large-scale deforestation for plantation agriculture in the hill country of Sri Lanka and its impacts	1998	Sri Lanka	Wickramasinghe (1998) showed that with the deforestation in Sri Lanka in hilly areas, the changes in rainfall pattern and temperature amplified and lead to climate changes. He further explained that all these changes are not uniform across the hilly regions recording significant changes in temperature increment and rainfall decline in some areas due to global warming and thus cause changes in land-use patterns, including tea.
25	Zhang, QW; Li, TY; Wang, QS; LeCompte, J; Harkess, RL; Bi, GH	Screening Tea Cultivars for Novel Climates: Plant Growth and Leaf Quality of Camellia sinensis Cultivars Grown in Mississippi, United States	2020	United States	Zhang et al. (2020) made an initiative to test how some selected cultivar adapted to the local climate in Mississippi, United States. They used nine tea cultivars and analyzed their growth, yield, and quality parameters, and identified that tea is generally growing well in that climatic conditions.
26	Jayasinghe, S. L., & Kumar, L.	Climate Change May Imperil Tea Production in the Four Major Tea Producers According to Climate Prediction Models	2020	Sri Lanka, Kenya, India, China	Jayasinghe and Kumar (2020) made an effort to assess how future climate (2050 and 2070) will influence tea species distribution in four major tea-producing countries, i.e., Sri Lanka, India, Kenya, and China the world using the MaxEnt niche modeling. As per their results, existing tea regions in Kenya, Sri Lanka, and China will decline optimal climate suitability by 2050 by 26.2%, 14%, and 4.7%, respectively, while the optimal suitability will be decreased by 15.1%, 28.6%, and 2.6% in Kenya, Sri Lanka, and China, respectively, by 2070. However, the future climate will bring blessing scenarios to the Indian tea sector as optimal suitability increase by 15% by 2050 and 25% by 2070.
27	Nanglae S., Nilthong R.	Predicting assam tea distribution in upper northern thailand using species distribution models	2015	Thailand	Aspect, annual mean temperature, mean temperature of the wettest quarter, annual precipitation, precipitation of the wettest month, and precipitation of the driest quarter all positively affected the model on tea suitability habitats. Furthermore, the most suitable areas were found to be predominantly in the north-northwest region of upper Northern Thailand (Nanglae and Nilthong, 2015).
28	Bore, J. K., & Nyabundi, K. W.	Impact of climate change on tea and adaptation strategies (Kenya)	2016	Kenya	There is a migration of tea to newer suitable areas in different countries if the current areas become vulnerable or even unsuitable in the future. By 2075, the suitability of tea-growing regions in Kenya is projected to decrease by 22.5%

References

1. Moher, D., et al., *Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement.* PLoS medicine, 2009. **6**(7): p. e1000097.
2. Oliver, S., K. Dickson, and M. Bangpan, *Systematic reviews: making them policy relevant. A briefing for policy makers and systematic reviewers.* EPPI-Centre, Social Science Research Unit, UCL Institute of Education, University College London, London, 2015.
3. Harris, J., et al., *How stakeholder participation can contribute to systematic reviews of complex interventions.* J Epidemiol Community Health, 2016. **70**(2): p. 207-214.
4. Leventon, J., et al., *An applied methodology for stakeholder identification in transdisciplinary research.* Sustainability science, 2016. **11**(5): p. 763-775.