

A report
On
Socio-economic impacts
of climatic change on tea production in Bangladesh

By

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Socio-economic impacts of climatic change on tea production in Bangladesh *Abstract*

Abstract

The study aimed to assess the present pattern of tea production and the impacts of rainfall patterns on tea yield and made tea quality. The cost of production and profit-loss were examined to link with rainfall distribution. Likewise, the daily income of permanent workers, the job market of the contractual workers, and the workers' associated welfare were critically analyzed to understand the social impact. The Rangpur division showed an incremental dryness; in contrast, the Sylhet division showed a steady pattern with a high frequency of continuous heavy rainfall. The rainfall pattern of the Chottogram division was highly unpredictable and oscillated. Long spell drought and heavy showers followed by flash flood affect tea yield. According to respondents' perception, the rainfall pattern showed changing behaviors that are not favorable for tea production. The emergence of new pests and deterioration of soil characteristics were reported. Bangladesh enjoyed the most pleasant weather for tea production in 2019. The cost of production increased with the adverse weather, which increases the loss for the growers. Profit loss of growers is a determinant of the welfare of the workers impacting their livelihoods. The organic tea garden is not affected by climatic events. Consequently, the socio-economic conditions of the organic garden are safeguarded. Hence, the study recommends following organic farming to cope with climate change. Differently, it was reported that the intermediaries' hegemony in the market chain is more problematic than climate change. Policy initiatives are warranted to correct the market and to establish growers and consumer's rights.

Keywords: Rainfall, cost of production, the emergence of pest, daily income, job market

Socio-economic impacts of climatic change on tea production in Bangladesh

Chapter-1: Introduction

Tea, a rainfed plant, grows across a wide range of climates and soils. The tea ecosystem comprises the tea plant, shade trees, the associated crops, and abiotic elements. Tea is a cash crop in Bangladesh, contributing a significant role in our economy and food security. Bangladesh obtained the 8th position in the production area, 10th position in production, and 12th position in exporting (ITC, 2020). In 2020, 167 tea estates in Bangladesh produced 86.39 million kg made tea, out of which 2.17 million kg were exported (BTB, 2021). Tea production largely depends on micro-climatic conditions, notably rainfall. Bangladesh is facing extreme weather and climate events for the last decades. The country encounters extreme weather events like circadian drought, prolonged precipitation, and late winter (Basher *et al.*, 2018; Mojid *et al.*, 2015). Bangladesh is one of the worst hits for climate change due to its geographical location is (Mishra *et al.*, 2019). Tea is considered one of the most vulnerable crops for climate change (Ochieng *et al.*, 2016). Tea leaf production is highly sensitive to both biotic and abiotic stressors (Cheruiyot *et al.* 2010). The drought drastically affects its production (Niinemets, 2015). In recent times, the rainfall distribution in tea-producing areas shows a remarkable variation (Dutta, 2014). The monsoonal rainfall affects the yield and the product's quality (Wijeratne *et al.*, 2007). The various study showed that the drought alters the metabolites' concentration (Ahmed *et al.*, 2014; Cai *et al.*, 2013; Eric *et al.*, 2019; Kfoury *et al.*, 2018; Han *et al.* 2017). Few studies measured the rainfall's impact on tea yield of a single or few tea gardens of *the Sylhet* district (Rahman *et al.*, 2017; Ali *et al.*, 2014). A study including all tea-producing areas will help better understand the change in rainfall distribution area-wise and the effect on tea yield and the quality of the products.

Chang and Brattlof (2015) reported that climate change has socio-economic impacts on tea production in India. Additional expenses to cope with the challenges cannot be balanced by increasing tea prices. In the market economy, the consumers buy the products by judging the price. Roy (2013) revealed that rainfall has a relationship with rural socio-economic conditions. Rain affects the total agricultural and industrial development of a country. The monsoonal rainfall influences local agricultural productivity and employment generations. In turn, the amount of rainfall determines the availability of water to meet various demands for agriculture, industry, hydroelectricity, and other human activities. Due to the declining

rainfall volume in Bangladesh, agricultural crop production decreases (Roy, 2013). With the decline of rainfall, *Sylhet* districts showed lower agricultural production. Hence, an evaluation of tea's yield and rainfall trend will help predict rainfall variability, changes in the seasonal pattern, and effect on this cash crop's production.

Some tea gardens encounter various problems like erosion of topsoil due to uncharacteristic heavy rainfall patterns, which harms production, increased use of fertilizers to maintain soil fertility, and increased pesticide usage, particularly during the dry season (Chang and Brattlof, 2015). Notably, there are several uncertainties due to climate change impacts that are not yet fully understood but could potentially affect future production levels, employment, and welfare of the growers and workers. These include the frequency of natural disasters, the proliferation of certain pests and diseases, and higher infrastructure costs. Quio *et al.* (2018) reported that tea cultivation is not only for cash earning but also plays a multidimensional benefit for both farmers and industrialists. Differently, organic agriculture has the potential to provide improved livelihood opportunities, increased income, and social benefits for resource-poor small-scale farmers. A comparative analysis between conventional tea cultivation and organic farming can help understand the importance of organic farming to adapt to climate change by ensuring grower's and worker's interests.

Therefore, there is a need to develop an integrated adaptive measure to cope with the changing climate by linking climatic impact with social impact. The fundamental unity of the knowledge ranging from pure science to social science is indispensable for adopting a better policy. Therefore, the study attempts to assess the present pattern of tea production and the impacts of rainfall variations on tea yield. Both quantity and quality of the yield are interconnected to the cost of production and loss-profit. The study also strived to assess the production cost associated with rainfall patterns. It is essential to examine how the worker's welfare in terms of daily income, overtime works, job market, and other facilities are affected by the production. Finally, the study came up with solutions to cope with climate change.

CHAPTER-2: CONCEPTUAL FRAMEWORK

Socio-economic activity persuades climate change; contrarily, the climatic variation affects the socio-economic activity. Both have a substantial interaction. Climate change impacts the gross domestic product and labor productivity (Matsumoto, 2019). Changing climatic elements causes the reduction of natural resources like water, which affects the people's socio-economic livelihood and health. Agriculture suffers from low productivity and yield, the prevalence of diseases, which results in increased poverty (Adjei-Mensah and Kusimi, 2020). The impact assessment of climate should consider two interrelated processes: socio-economic impact and climate change. The change in socio-economic activities has not been sufficiently incorporated in impact assessment (Berkhout et al. 2002). Hence, the study integrated the difference in socio-economic conditions systems to assess the impact of climate change.

Over 80% of the whole population of Bangladesh lives in the rural sectors. As the deltaic floodplain, Bangladesh is highly sensitive to climatic variation. The predominant agricultural economy is interconnected with the monsoonal characteristics, notably the pattern of wet and dry seasons (Ericksen *et al.*, 1996). The changes in climatic variables have severe implications for the local economy and community' welfare. Changes in tea yields and quality of made tea may negatively impact the economy and gardeners' and workers' livelihoods (Ahmed *et al.*, 2018). The study explored this theme. The ecology also depends of much anthropogenic and non-anthropogenic perturbation, which impact together. The study stressed only rainfall distribution as it determines tea production primarily (Wijeratne 1996). Ironically, the tea gardeners do not keep data on maximum temperature, minimum temperature, mean temperature, humidity, day length, light intensity, dew points, soil temperature, soil chemistry and physics, slope, organic matter contents, etc. The study aimed to assess the rainfall's impact on yield and other socio-economic impacts (Figure 1). The main relationships among rainfall, tea yield, and workers' welfare were embraced as climate change's socio-economic impact. This theme was explored through four main questions: What is the trend of tea yield in Bangladesh? How does the rainfall pattern affect the yield and quality of the product? How are the gardeners affected in terms of cost-benefit analysis? What are the consequences on the workers? And what should be the remedies?

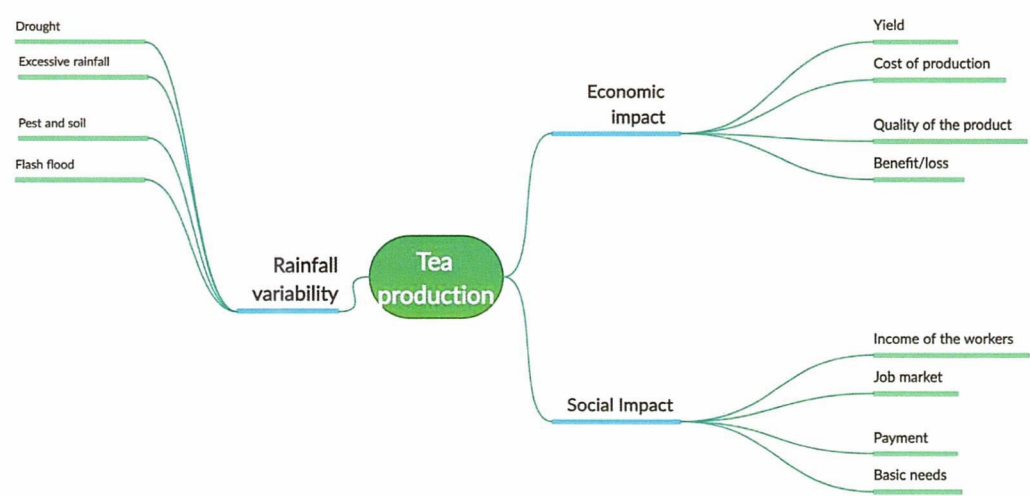


Figure 1: Conceptual framework of the study

CHAPTER-3: METHODOLOGICAL FRAMEWORK

The study collected both primary and secondary data for the period from November 2020 to March 2021. Both qualitative and quantitative data were exploited in the research. The existing literature related to the socio-economic impact of climate change was studied to understand the broader picture of the collected data and develop a theoretical framework for this paper. A stepwise systematical research approach was used for a better outcome (Figure 2).

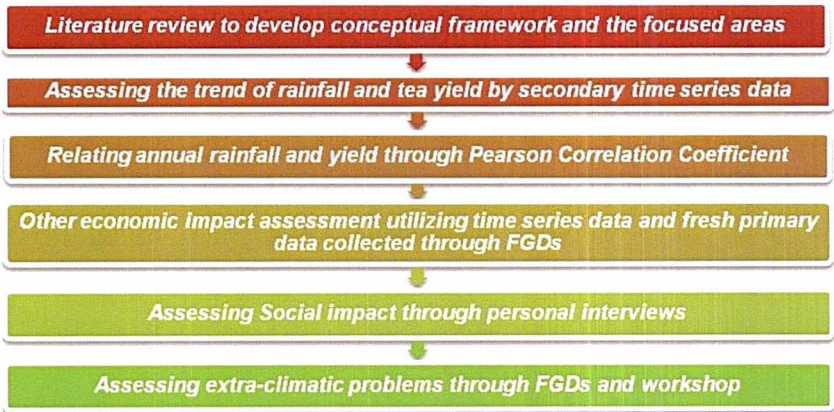


Figure 2: Methodological framework

1.1. Assessing the trend of rainfall and tea yield

Ten tea gardens were taken from three tea-producing administrative divisions: *Sylhet*, *Chattogram*, and *Rangpur*, which covered 06 administrative districts, namely *Sylhet*, *Moulvibazar*, *Hobiganj*, *Panchagarh*, *Chottogram*, and *Rangamati*. The recorded data on monthly rainfall and tea yield from 2010 to 2020 were collected from each garden. In addition, secondary data on the national yearly tea production of the same duration were collected from Bangladesh Tea Board. For a broader understanding, tea production time in India, Sri Lanka, and China was used from the source of statistica dot com.

1.2. Relating annual rainfall and yield

The annual rainfall was defined as the independent variable and tea yield as the dependent. Pearson correlation coefficient (PCC) determined the nature of the relationship. Eleven years' data (2010-2020) of 10 gardens were used in this calculation. In addition, simple descriptive analysis was followed to correlate yield with rainfall pattern.

1.3. Other economic impact assessment

A comparative assessment of the cost of production and profit/loss per hectare area between the years 2019 and 2020 was done based on the tea gardens' data. A focus group discussion was held at each garden to understand the changing behavior of rainfall patterns and associated problems like the emergence of new pests and their effects on the products' quality. The focus group discussion helped to find out the deeply rooted problems.

1.4. Social impact assessment

A total number of 30 workers were selected purposively from each garden. Among them, 15 were permanent workers, and the rest was a temporary or contractual worker. Random sampling was followed in selecting the respondents irrespective of gender. They were interviewed with a semi-structured questionnaire focusing on daily income, monthly employment of the temporary workers, payment regularities, housing facilities, and sanitation status. Based on the collected data, a comparative assessment between the years 2019 and 2020 was accomplished.

1.5. Assessing extra-climatic problems

The study analyzed the key actors of tea markets and assessed the profit/loss of the intermediaries based on the data collected from FGDs. In addition, a consultation workshop was held in Chittagong, where the tea growers and representatives from the warehouse, brokers, and buyers were present. Telephonic interviews were done with the senior management of the Bangladesh Tea Board.

CHAPTER 4: RESULTS AND DISCUSSION

1.6.Yield (made tea) trend from 2010 to 2020

It was found that the average yield in the study area ranged from 1015 kg/ha to 1466 kg/ha. The highest yield was counted in 2019, followed by 2016 and 2020. Contrastingly the lowest yield was observed in 2011. The annual production per hectare area remained almost symmetrical in 2010-12, 2014-15, 2017-18, and 2020. The trend continues on an upper path.

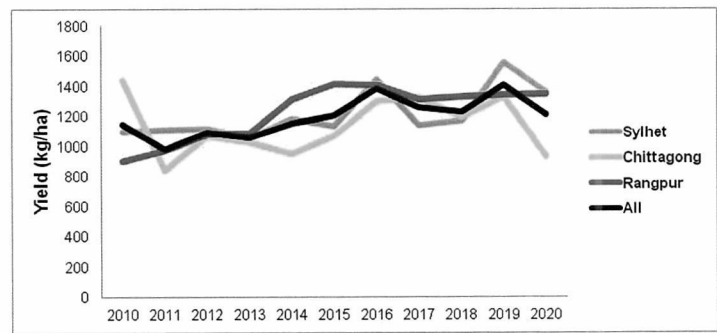


Figure 3: Trend of annual rainfall and tea yield in the study area

Among the tea-producing administrative divisions, Chottogram exhibited a highly choppy trend of yield. The highest yield was enumerated in 2010, and the lowest in 2020. Despite oscillation, *Sylhet* division gradually increased its yield. *Rangpur* division maintained a gentle uptrend, which maximized its yield during 2014-2017.

The tea yield trend per hectare in the whole study area is mirrored by the national production trend (Figure). The highest annual national production (96.07 million kg) was recorded in 2019, followed by 2020. The lowest national production (59.13 million kg) was found in 2011. In the rest years, the annual national output ranged from 60.04-85.05 million kilograms.

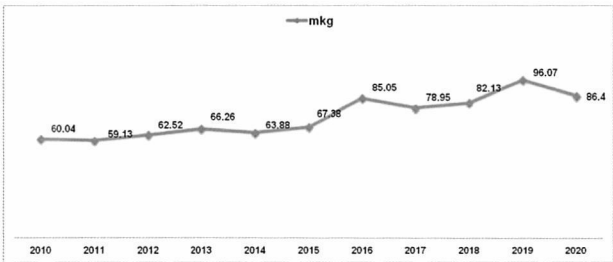


Figure 4: National production trend yearly

Bangladesh showed an increasing production trend from 2016, and in 2020 the production increased by 1.40 times compared to 2010. The country could not maintain the consistency of 2019's record in 2020. Among other major tea-producing countries of Asia, China doubled its production from 2010 to 2020. India showed a consistent and gradual increase from 2010 to 2020. Tea production of India was 1.5 times in 2020, considering 2010 as a baseline. Sri Lanka exhibited almost a flat trend in annual production.

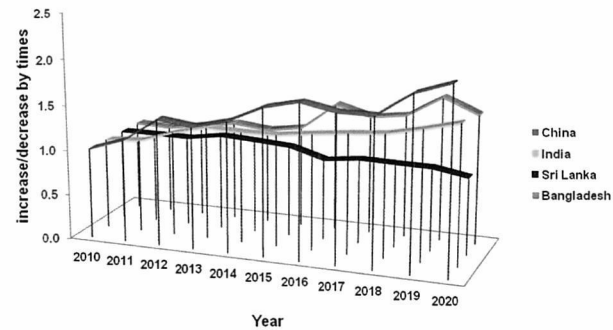


Figure 5: Annual production trend of major producing countries of Asia

1.7. Impact of rainfall on tea yield

1.7.1. Rainfall trend from 2010 to 2020

By taking the monthly average rainfall in the study area from 2010-2020, the highest rainfall was recorded in June, followed by July, August, May, and September. The average rain varied considerably from year to year. The highest rainfall was enumerated in July 2019 and 2020. The year 2014 faced 03 months-long drought conditions.

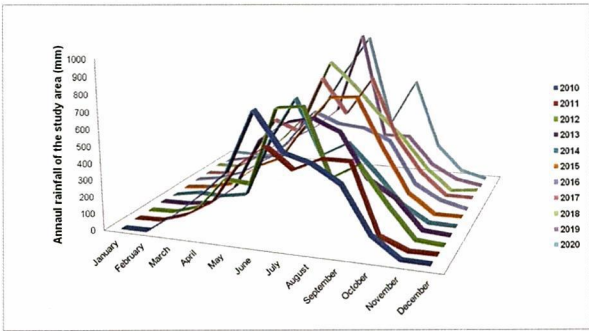


Figure 6: Monthly rainfall pattern during 2010-2020

The Sylhet division showed a symmetrical average monthly rainfall pattern. In July 2020, this division enjoyed heavy pouring (1059 mm), the monthly highest record from 2010 to 2020 considering the entire study area. One week-long continuous overweighted downpour caused flooding in the tea gardens. Likewise, 2014 faced 03 months-long droughts. A total number of 06 months was counted from 2010-2020 in this division. Except that drought is not a problem there.

Table 1: Monthly rainfall pattern and yield during 2010-2020 in Sylhet division

Year	Rainfall (mm)												Σ	Yield ha/kg
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec		
2010	0	4	269	648	569	751	499	499	574	165	0	31	4010	1094
2011	14	11	131	227	544	522	545	414	333	130	13	18	2902	1109
2012	11	13	141	311	358	772	496	460	235	116	15	2	2930	1114
2013	3	16	92	342	602	714	480	465	275	240	44	8	3282	1055
2014	0	21	52	141	646	458	385	463	480	174	0	0	2819	1177
2015	5	32	42	239	498	503	429	623	551	58	10	2	2994	1135
2016	13	45	116	524	566	582	463	512	423	118	36	1	3397	1444
2017	10	56	288	747	475	713	490	570	416	226	56	54	4101	1136
2018	9	61	282	430	641	883	612	709	461	214	8	66	4375	1168
2019	4	40	100	243	528	790	829	441	341	181	22	11	3531	1556
2020	11	24	49	281	615	994	1059	419	530	288	16	0	4288	1356

The Chottogram division showed a little bit asymmetrical average monthly rainfall pattern. The monthly as well as yearly rainfall average is highly fluctuating. The month June received the highest average rainfall during July, August, and September during 2011-2020. The year 2013 faced an almost 05 months long consecutive drought. In 2014, the division yielded less because continuous heavy pouring in the month of June caused a short-lived flash flood, and the month of July was comparatively drier. In 2010 and 2019, only January month was

rainless. The year 2020 experienced two spells of short-lived drought: February-March and December. The rest years encountered more than 01 month-long dry seasons.

Table 2: Monthly rainfall pattern and yield during 2010-2020 in Chottogram division

Year	Rainfall (mm)													Σ	Yield ha/kg
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec			
2010	0	7	70	39	273	658	311	344	156	192	24	15	2089	1437	
2011	0	13	39	113	366	639	313	560	505	70	0	0	2619	840	
2012	0	14	31	282	136	771	644	309	303	385	20	0	2895	1068	
2013	0	0	1	79	566	396	318	326	303	249	0	0	2238	1022	
2014	0	34	16	14	352	859	252	469	284	130	10	0	2420	950	
2015	0	0	21	239	132	702	1192	799	547	303	1	16	3954	1066	
2016	0	49	98	18	322	321	554	433	212	129	82	0	2218	1298	
2017	0	0	83	436	337	1161	887	641	596	183	10	14	4349	1321	
2018	43	2	15	257	424	1053	715	334	197	188	3	0	3231	1194	
2019	0	54	34	98	239	331	1251	340	329	126	69	3	2874	1328	
2020	54	2	0	179	298	310	474	381	390	323	119	0	2530	930	

Rangpur division showed a decreasing trend of annual rainfall except 2010 and 2020. A prolonged drought in the dry season is apparent. The month of May received about half of September, which indicates a long spell drought. Contradictorily, only 2011 enjoyed the year-round shower. The year 2010 and 2016 experienced 04 months long consecutive drought. The division faced 29 months long rainless period during 2010-2020.

Table 3: Monthly rainfall pattern and yield during 2010-2020 in Rangpur division

Year	Rainfall (mm)												Yield	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Σ	ha/kg
2010	0	0	0	57	360	903	824	653	469	49	28	0	3342	900
2011	6	11	27	143	290	413	351	470	612	23	9	10	2365	973
2012	4	6	6	147	218	582	1044	192	717	106	0	0	3023	1081
2013	18	17	3	39	241	644	1070	867	295	89	0	0	3282	1085
2014	4	39	12	11	282	766	425	406	87	0	0	0	2032	1314
2015	4	26	112	84	152	252	406	650	66	0	0	0	1753	1415
2016	0	0	48	31	132	713	406	432	533	142	0	0	2438	1405
2017	6	0	114	84	265	298	130	1019	105	58	0	0	2080	1310
2018	0	0	50	94	230	464	638	393	324	3	0	7	2204	1329
2019	0	18	37	279	147	206	793	95	219	51	0	0	1845	1343
2020	0	30	15	157	293	722	1218	220	994	8	0	9	3668	1347

1.7.2. Relationship between rainfall and yield

The study revealed that the annual rainfall volume could not influence tea yield. There was a slight negative relationship between average rainfall and yield. In another study, Rahman *et al.* (2017) found a similar remote negative relationship in the *Malnichara* tea estate of the *Sylhet* division during 2012-2017. The expected average annual rainfall for the excellent tea leaf production in Bangladesh was 4000-4600 mm (Ali *et al.*, 2014). Ochieng *et al.* (2016) revealed that a consistent rainfall pattern is the determinant of high productivity, and any significant deviation affects the production. Wijeratne *et al.* (2007) reported that very high rainfall reduces sunlight's availability, which turns down photosynthesis. Similarly, excessive rain causes waterlogging conditions, which affects soil saturation and the plant's absorption capacity.

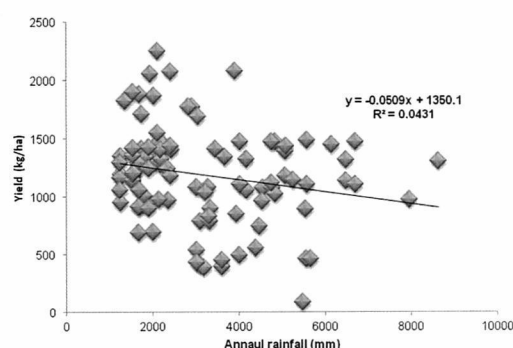


Figure 7: Relationship between average annual yield and annual rainfall of 10 tea gardens

The study area's average rainfall was the lowest in 2011, though the least amount of rain was recorded in 2014. Despite year-round rain in 2011, *Sylhet* division produced lower but not the least. The division exhibited high resilience in 2014 though it experienced three months-long droughts and the lowest annual rainfall. The respondents from this division argued that they introduced a sprinkler irrigation system in that year to cope with the drought from the very beginning. Resultantly, the national production and the yield of the study area were not the worst hit. In 2010, the division enjoyed year-round rainfall, and it could not predict 03 months prolonged drought in advance. Due to lack of preparedness, not only the study area but also the country produced the least.

Similarly, despite enjoying the highest rainfall in 2017, the maximum production per unit area was 2019. The *Sylhet* division gained very balance and even rain distribution this year. Consequently, the national production was the highest in that year though national production

represents yield and cropped areas. The *Chottogram* division, the second-largest tea-producing division, responded similarly as this division faced minimal dryness in that year.

Sylhet and *Chottogram* division could not maintain their productivity of 2019 in 2020. *Sylhet* division faced dry December and flooded July. The *Chottogram* division's yield sharply fell in 2020 due to unusual dryness in the month of February and March. Despite the incremental dry season, the yield is not affected in the *Rangpur* division as the rainfall distribution does not fluctuate regularly. Only one tea garden, *Kazi and Kazi*, was taken as a sample from that division, which is the only organic tea garden. The respondents opined that *Kazi and Kazi* Tea Estate have high resilience capacity, and this tea garden has taken high adaptive measures knowing the distinct micro-climatic pattern. This garden established a modern sprinkler irrigation system. Simultaneously, it uses mulches to conserve soil water and protect the soil from further evaporation. Instead of chemical fertilizer, it adds organic matter to the soil, which has a high water holding capacity. They increased the density of the shade trees to protect scorching. Neem (*Azadirachta indica*), *Basak* (Malabar Nut), *Bish kanthali* (Knotweed), and *Nishinda* (Chaste Tree) are used as shade trees that are strong repellent against insects and pests. The respondents argued that rainfall distribution could not affect the production of this tea estate.

It is evident that among 03 tea-producing divisions, *Sylhet* faces occasional flash flood and *Rangpur* encounters with drought. As a hilly area, the water of the flash flood cannot stand for a long time. On the other hand, the tea gardens' soil texture in this division is sandy loam, which helps in draining out the water very quickly. Neither flash flood nor a short-lived drought can hamper the production of this division significantly. On the flip side, *Kazi and Kazi* of the *Rangpur* division established tea gardens on the flat terrain comprised of sandy loam soil. This tea garden encounters flash floods on a rare occasion. Consequently, the management schemes focus only on the predictable drought. Organic farming systems and strong adaptive measures safeguard the production trend in this division. Ironically *Chottogram* division suffers from unpredictable drought and flash flooding. As a result, the tea growers cannot make dense shade trees to combat drought. The high density of shade trees in case of flooding prolongs the water logging condition. The higher altitude than other divisions cannot help in draining out the water quickly as the soil texture ranges from clayey loam to loam. It can be argued that *Chottogram* is the only affected tea-producing division due to oscillated rainfall pattern.

Short-spelled rainfall is favorable for tea production, and in contrast, long-spelled rain reduces tea yield (Esham and Garforth, 2013; Duncan *et al.*, 2016). Consistent rainfall patterns can boost up production (Ochieng et al., 2016). Likewise, the tea-producing areas should enjoy a wet and or a combination of the alternative wet and dry season. The rainfall pattern and its distribution determine tea’s quality (Boehm 2016). Continuous cloud coverage followed by rainfall hinders bush growth and plucking during peak harvesting time (Boehm *et al.*, 2016). The studies showed that the micro-climatic variables became unpredictable, erratic, and extreme for tea production (Dutta, 2014; Marx et al. 2017). The rainfall determines not only the yield but also the quality of the made tea. Heavy rain dilutes the phytochemicals and changes tea's taste, deteriorating the quality (Han et al. 2017).

1.7.3. Respondents’ perception about rainfall distribution and associated problems

The respondents of the focus group discussions identified several problems originating from rainfall patterns. The tea gardeners from all divisions admitted that they do not receive rainfall in their usual ways. The rain is uneven and does not help the growers. The over-shower in the monsoon cannot help but sometimes creates flood and waterlogging conditions. A minuscule pouring in the dry season, notably from November to February, can boost production. Nighttime rainfall is highly desirable as it does not hamper photosynthesis and plucking. They opined that precipitation occurs in the daytime mainly. It is reported that the soil of the *Chottogram* divisions shows unpredictable behaviors like rainfall and yield. All tea gardeners from the division said that the soil is deteriorating sharply.

Table 4: Rank of the identified problems in FGDs (Ascending order)

<i>Sylhet</i>	<i>Chottogram</i>	<i>Rangpur</i>
• Uneven distribution of rainfall in the monsoon • Circadian heavy continuous pouring in the rainy season, which causes flash floods frequently. • Scarcity of irrigation water due to lowering of	• Very unpredictable and sporadic rainfall throughout the year • Water scarcity in the dry season and occasional flash flood in the monsoon	• Predictable prolonged drought • Rare flash flooding • Unnecessary rain in the rainy season • Daytime precipitation is more than nighttime

the water table • Daytime precipitation is more than nighttime	• Due to erratic rainfall, the soil cannot maintain its usual characteristics • Soil is becoming more acidic	
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1.8. Economic impacts of rainfall variability

1.8.1. Emergence pests and effect on made tea’s quality

The Chottogram division respondents reported that tea mosquito bugs (*Helopeltis Theivora*) and Red spider mite (*Tetranychus urticae*) was a minor pest historically. Still, in recent times they have become significant devastating pests. Consequently, they have to go for the frequent foliar spray, which increases production cost and decreases the made tea ‘quality. The regular foliar spray may be harmful to the consumers in terms of health hazards. Al-Mamun *et al.* (2016) revealed that the made tea's physiological and biochemical contents are significantly reduced with the increase of infestation of red spider mites. It was recorded that the nymphs and adults of the tea mosquito bugs suck the sap from the tender leaf, bud, and new shoots, which causes low yield. Roy et al. (2015) reported that the insect's salivation and oviposition damage the plant's tissues, resulting in crop loss. Like *Chittogram* division, these two insects are the primary pests in the *Rangpur* division. The *Kazi & Kazi* tea gardens planted shade trees that have repellent characteristics. Consequently, this organic tea garden has developed resilience and adaptive capacity to respond to the pests' attacks. Climate change decreases the quality and the quantity of tea yield by increasing soil erosion, pests’ infestations, and outbreaks of diseases (Wijeratne 1996).

Table 5: Emerging pests in different areas

<i>Sylhet</i>	Looper Caterpillar, Thrips, Jassid, Crown gall disease
<i>Chottogram & Rangpur</i>	Tea mosquito bug, Red spider mite

1.8.2. Increased/decreased production cost in 2020 associated with rainfall

Afifa Nagar and *Lallakhal* tea estate under *Sylhet* district spent more money in 2020 in purchasing fungicide than in 2019. Record rainfall in July 2020 caused root rot disease in seedlings and younger plants. *Lachatoorah* tea garden of the same district encountered short-lived drought and moderate insect attacks. *Satgaon* and *Ichamoti* tea estate of *Moulvibazar* district suffered from the scarcity of irrigation water in 2020 due to lowered water table. The gardeners paid more incurred in irrigation. *The Surma* tea garden of *Hobiganj* district faced slightly higher acidity in 2020 due to a short spell of drought in January 2020. *Kodela* and *Karnafuli* of the Chottogram division had to face both drought and short-lived drought. In addition, *Kodela* experienced a massive attack of tea mosquito bug and red mite. More expenditure of *Wagachhara* tea estate of *Rangamati* district was associated with increasing soil pH and weed control. *Kazi & Kazi* spent huge money to go for organic farming in the initial stage. It did not pay any additional money in 2020.

Table 6: Extra cost involved to cope with rainfall variation

<i>Tea gardens</i>	<i>Weedicide</i>	<i>Insecticide</i>	<i>Fungicide</i>	<i>Irrigation</i>	<i>Dolomite</i>	<i>Total</i>
<i>Afifa Nagar</i>	0	0	1200	0	0	1200
<i>Lallakhal</i>	0	0	1400	0	0	1400
<i>Lachatoorah</i>	0	800	0	2200	0	3000
<i>Surma</i>	0	0	0	0	800	800
<i>Satgaon</i>	0	0	0	4000	1200	5200
<i>Ichamoti</i>	0	0	0	3600	800	4400
<i>Karnafuli</i>	0	0	1300	2600	0	3900
<i>Kodela</i>	0	1200	1300	3600	0	6100
<i>Wagachhara</i>	500	0	0	0	600	1100
<i>Kazi & Kazi</i>	0	0	0	0	0	0
<i>Mean</i>	50	200	520	1600	340	2710

1.8.3. Profit/loss analysis

The profit/loss was calculated for the year 2020 based on data provided during focus group discussions. In 2020, the gardeners pegged massive revenue loss due to mainly pandemic corona 19. Also, the pandemic corona 19 played a crucial role in surging the cost of production and decreased the market price due to lower consumption. The loss was exaggerated by rainfall-related factors (Table 7). According to respondents' perceptions, the

production cost depends on the overhead expenditure, type of ownership, branding, quality of the products, nature of employees, bargaining capacity with the brokers and buyers, and management. Out of the ten tea gardens, *Satgaon*, *Ichamoti*, and *Kodala* tea gardens experience continued loss. *Satgaon* and *Ichamoti* continuously encounter the lower water table. On the other hand, *Kodala* tea garden simultaneously faces uneven rainfall and the emergence of devastating pests. *Surma* and *Kazi & Kazi* are running without any losses. *Waggachara* tea estate can minimize the loss as their permanent employees are the minimum. This family-run tea garden does not employ any managerial level staff. Consequently, its overhead cost is nearly zero. The gardeners surmised that rainfall affects the quality and production cost. In the continuous heavy rain, the permanent workers cannot work, but they are paid. The moisture contents of the leaf increase, and consequently, the drying cost increases. Contrastingly, in case of prolonged drought, the leaf becomes scorched.

Table 7: Profit/loss of the gardeners for the year 2020

	Production cost (BDT)/kg	Sell (BDT)/kg	Profit (+)/ Loss (-) /kg
<i>Satgaon</i>	200	195	-5
<i>Ichamoti</i>	200	177	-23
<i>Lackatoorah</i>	165	142	-23
<i>Afifa Nagar</i>	200	185	-15
<i>Lallakhali</i>	208	184	-24
<i>Surma</i>	165	192	+27
<i>Telipara</i>	180	165	-15
<i>Kornafuli</i>	220	220	0
<i>Kodala</i>	230	210	-20
<i>Kazi and Kazi</i>	240	240	0
<i>Waggachara</i>	204	185	-19
<i>Average</i>	201.1	190.5	-10.6

1.9.Social impact

1.9.1. Reduced income

The workers are categorized as temporary (contractual) and permanent. They are mainly responsible for seedling plantation, leaf plucking, foliar spraying, withering, weeding, cleaning, transporting, cleaning, spraying pesticide, and other intercultural operations. A

worker's task is defined by the plucking of 18-24 kg of leaves per day at the cost of 120 Bangladesh Taka. A portion of this wage is deducted to add provident and religious funds and the union membership fee. Besides, the workers enjoy five kilograms of rice or flour as a ration meal per week, free housing, and medical care from the owners. To avail these facilities a worker must work 05 days in a week. A worker gets 4.5 takas for plucking one kg of the leaf as overtime work out of a task. It is revealed that a worker earned 120-450 taka per day, counting overtime work. The average daily income was 240 takas/worker/day in 2019, which decreased to 224 takas in 2020 (Table 8). The workers reported that they could not pluck leaves beyond their tasks in extreme weather and henceforth low yield.

Table 8: Average daily wage of a permanent worker in 2019 and 2020

Year	Range		Average
	Min	Max	
2019	120	450	240
2020	120	430	224

1.9.2. Job loss

The study found that 77% were permanent the rest was temporary or contractual (Figure 8). Hossain et al. (2017) reported that 70.6% of workforces were employed permanently, while 29.4% were used contractually. The respondents opined the employment of temporary workers depends on yield, cost of production, and profit.



Figure 8: Permanent and temporary worker’s ratio

Usually, the temporary or contractual workers are employed during peak plucking season (May-October). In 2019, the temporary worker's average working months was 4.42, which fell off to 3.17 in 2020 (Figure 9). The employment generation and daily income depend on climatic variables like rainfall. The gardeners try to minimize the cost of production in low

yield due to climatic variables by contracting the contractual workers' job market. Similarly, the overtime work of the permanent workers is hampered. The *Kazi & Kazi* is exceptional as this company runs organic dairy farming along with tea production. Huge cow dung is required for organic fertilizer and for producing biogas. This company has brand organic milk products. The garden owners provide loans to the workers for purchasing dairy cattle, and the workers pay back the loan by selling milk and cow dung at market price. Consequently, their income does not depend on tea leaf plucking only. The workers of this tea estate have enriched their livelihoods.

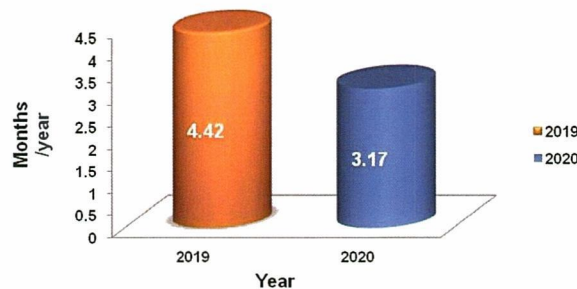


Figure 9: Months of employment of the temporary workers in 2019 and 2020

1.9.3. Irregularity in wage payment

Irregularity in wage payments was reported in low yield and increased cost of production due to climatic variability. Sometimes, it is tough to pay the workers on the weekend regularly. 79.6% opined that the garden owners could not pay them every weekend due to a shortage of money flow among the permanent workers. By considering the living expenses, periodic payment causes extra challenges in maintaining a decent livelihood. The workers of *Kazi & Kazi* do not encounter such problems.

1.9.4. Inconvenient paying back of provident fund

The permanent workers deposit 7.5% of basic pay as the provident fund started at 18 years old and ended at 60 years of age. At the time of retirement, they receive double the deposited money plus the bank's interest rate. The respondents except *Kazi & Kazi* opined that the gardeners could not repay the provident fund timely in production loss.

3.5. Extra-climatic problems

3.5.1. Profit-making by the intermediaries

The tea gardeners argued that with lower domestic consumption due to corona and lower sell price, the retailer price was steady. The producers were highly affected, and the consumers did not pay less money in purchasing packed tea. The intermediaries, notably buyers, secured

the highest return (Table 9). In addition, they have to pay transportation costs to carry the made tea to the warehouses. They have to pay 01% commission to the brokers and 01% of the selling price as cess to the government. The brokers also get a 01% commission from the buyers. In total, they earn 02% of the producer's sell price without any investment. The buyers have to pay 15% of the producer's sell price. By purchasing made tea from different gardens, they grade and blend mixed tea. Finally, the tea is dressed with the new packet in the name of buyers. The buyers' expenditures are also associated with advertisement, marketing, and transportation. The wholesaler buys from the buyers and stores in their godowns. The retailers' prices highly fluctuate as it depends on consumers' bargaining capacity. The respondents argued that the buyers exploited three cases: high production, heavy rainfall, and lower consumption. In the chance of high rain, they reduce the producers' price in the name of high moisture content. In anticipation of increased production and lower consumption, they sharply contract the price mentioning the demand and supply relationship. It was also reported that few buyers are highly united and syndicated, and they determine the fate of the producers.

Table 9: Profit/loss of the market players

	Items	Mean (BDT)
<i>Producer</i>	<i>Expenditure (production cost, transportation, warehouse charge, Broker's cost, and cess)</i>	196.9
	<i>Sell</i>	186.7
	<i>Loss</i>	10.2
<i>Broker</i>	<i>Expenditure</i>	0
	<i>Profit</i>	3.74
<i>Warehouse</i>	<i>Expenditure (maintenance)</i>	0.94
	<i>Profit</i>	2.8
<i>Buyer</i>	<i>Buy</i>	186.7
	<i>Expenditure</i>	70
	(VAT, Broker's commission, grading, blending, processing, packaging, transportation)	
	<i>Sell</i>	300
	<i>Profit</i>	43.3
<i>Wholesaler</i>	<i>Buy</i>	300

	Expenditure (Transportation, storage)	12
	Sell	325
	Profit	13
Retailer	Buy	325
	Transportation	7
	Sell	350
	Profit	18
Consumer	Buy	350

3.5.2. Other regulatory problems

Bangladesh Tea Board (BTB) is an autonomous body responsible for drafting laws, rules, and public policies regarding tea production and the management of the tea sector. The gardeners believe that BTB always upholds the buyers' interests and rarely cares about the producers' welfare. The buyers have benefitted from the existing regulatory framework. Other farmers buy agricultural inputs like fertilizers, pesticides, and machinery at a subsidized rate, except the tea growers. On the other hand, the rest agricultural sectors pay electricity charges for irrigation purposes at a household rate, but the tea growers are charged with a high commercial rate. The government helps the farmers in various ways and provides various incentives to boost up agricultural production. Contrarily, the government imposes 1% cess and 15% VAT on the tea products despite being an agricultural crop.

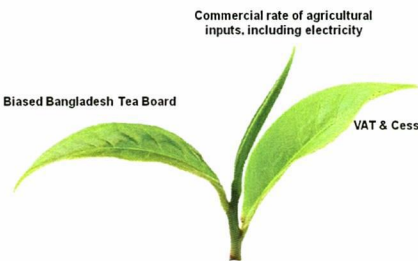


Figure 10: Regulatory problems

CHAPTER 5: WHAT TO DO?

Following Kazi & Kazi model: *Kazi & Kazi*, the only organic tea garden of Bangladesh, has developed a highly resilient farming system against any adverse effect of climatic variables like drought. As it produces premium quality organic tea, it makes a profit under any circumstances. It has developed associated organic dairy entrepreneurship, which boosted the workers' socio-economic conditions and the company. The other tea estates can follow organic farming to avoid gradual tea production loss and improve the workers' living standards. On the other hand, this is essential for ensuring pure, safe, and health hazard beverages. *Albizia odoratissima*, *A. Chinensis*, and *A. lebbek* are commonly used in other tea gardens among the shade trees. These shade trees should be gradually replaced by *Neem* (*Azadirachta indica*), *Basak* (Malabar Nut), *Bish kanthali* (Knotweed), and *Nishinda* (Chaste Tree) to combat emerging pests.

Considering tea as an agricultural crop: Like other crops, tea growers should enjoy government subsidies in purchasing agricultural inputs, including fertilizers, pesticides, electricity, and different types of machinery. Government should exclude this sector from paying cess money and VAT. This stimulus will help the growers to restore their confidence level and to minimize the losses.

Clearing intermediaries from the market chain: According to the growers' perception, the intermediaries' incremental hegemony in the market chain is causing more problems than climate change. Neither the head (the growers) nor the tail (the consumers) is benefitted from the existing market systems. Most of the growers face loss in most of the years, but the intermediaries, notably the buyers, make huge profits. SDG target 2.b. stresses on correcting the market chain and clearing all obstacles to ensure food security. Therefore, it is recommended that the government intervene to remove those intermediaries from the market chain or limit their profits to save both producers and consumers.

Crop insurance: Tea producers should be obliged to bring under the umbrella of risk insurance to transfer the production loss into monetary compensations.

Integrated adaptive measures: The drainage and irrigation systems should be modernized to protect the plants from waterlogging and drought, respectively. Establishing a sprinkler irrigation system may ensure efficient water resources use and minimize the adverse effect of drought. Applications of indigenous knowledge can be encouraged. Bangladesh Tea Research Institute should work intensively to develop drought-resistant varieties. Integrated nutrient

management can combat nutrient deficiency and drought simultaneously. The pruning litter and shade tree droppings should be preserved and added to the soil to increase the soil's organic matter and water holding capacity.

Worker's floor protection: The workers should be considered part of society's mainstream and left-behind group. The government should incorporate them into all safety net programs administered by various public departments. Only the tea growers cannot ensure their wellness and meet basic needs. Besides, the government can encourage local, national, and international Non-Government Organizations to improve the workers' socio-economic conditions.

CHAPTER-6: CONCLUSIONS

The tea sector of Bangladesh has multidimensional importance in earning foreign currency, employment generations, food security, green coverage, sustainable land use, and biodiversity conservation. The land of most of the tea gardens is *Khas* (government-owned land) in nature. Each garden is a chunk of land which the government can use for many purposes. If the tea plantation is stopped, the land is grabbed overnight. On the other hand, Bangladesh's natural forest habitats have become lost, degraded, and fragmented, creating remnants. Consequently, the tea gardens are gradually being turned into a wildlife sanctuary. Therefore, this sector should be survived at least, for nature conservation. This study used a dataset of monthly rainfall, which is only available in the tea gardens. The data on various climatic variables should be recorded to understand to assess the impacts of multiple stressors. Future research should focus on the causal factors of emerging new pests and the remedies avoiding chemical pesticides to ensure safe and pure beverage. Bangladesh may witness more extreme climate events in the future. The profitable tea sector is interconnected with achieving many goals of SDGs. It reduces poverty (SDG 1), ensures food security (SDG 2), and creates decent jobs (SDG 8). The women workers have established equal rights to financial resources (SDG 5). The green coverage helps in maintaining carbon footprint. SDG 15 urges to protect the biodiversity, notably the rare species, what tea gardens do. Simultaneously, SDG 13 advocates for the actions to cope with climate change. Target-1.5 of SDGs draws attention to build a resilient society to absorb climatic shocks. Hence, the tea sector warrants policy initiatives to achieve SDGs. The tea should enjoy government stimulus like other crops. On the other hand, the policy should be producer and consumer-friendly. The obstacles should be cleared to protect the gardens from the adverse effect of climatic events and to ensure the welfare of the growers and workers.

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