Kushtia College Journal Vol.1 Issue 1 *ISSN 3006 – 1741*
Pp.63- 94 *Deforestation and Micro-Climate: A Case on Chittagong Hill Region of Bangladesh*

Deforestation and Micro-Climate: A Case on Chittagong Hill Region of Bangladesh

H.Z.M. Hasibush Shaheed[1]

[1]Dr.H.Z.M. Hasibush Shaheed is a Professor in Geography and Environment, Kushtia Government College, Kushtia. e-mail: dr.hasib1966@gmail.com

Abstract

Once the hill region of Chittagong represented very dense evergreen and deciduous forest. But maximum portion of forest has been depleted in recent decades due to repeated excessive slash and burn practice for monoculture of commercial plantation, jhum cultivation and settlement. As a result, the region has been suffering from excessive heating and dryness. But the places of deep forest represent different feature. To measure the micro-climatic variation due to deforestation, direct field reading of temperature and humidity from selected sampling places have been used. Public opinion from different places have been collected through PRA techniques (PRA Sessions, Key Informants Interview, Mini Survey, Trend Analysis). Secondary data have been used for comparison or establish the primary data or explaining it. Different statistical techniques, *ie*, bi-variant correlation, paired sample test and regression analysis have been used to reveal actual relationship between forest cover and climate. The research shows different microclimatic condition in natural forest clad area and other places. It also reveals significant change in micro-climate due to commercial gardening or deforestation.

keywords: microclimate, climate, forest, deforestation

Introduction

The term 'microclimate' refers strictly to combination of local atmospheric factors differing from the prevalent general climate (macro-climate) of the region. This is owing to the uneven topography, plant cover etc. The microclimates are recognizable only in a very small area and they are sufficient to induce remarkable local variations in type and composition of flora. In a dense forest tall trees are exposed to high intensities of light and temperature but shrubby plants growing in the shades of trees do not get the same climatic condition. Climatic conditions of a particular region vary at different trees both vertically and horizontally (Puri 1994). Microclimate above the forest canopy, which is similar to that, in a large clearing is substantially different from that near the floor below nature phase forest (Whitmore 1990). A **micro climate** (or **micro-climate**) is a local set of atmospheric conditions that differ from those in the surrounding areas, often slightly but sometimes substantially. The term may refer to areas as small as a few square meters or smaller (for example a garden bed, underneath a rock, or a cave) or as large as many square kilometers. Because climate is statistical, which implies spatial and temporal variation of the mean values of the describing parameters, within a region there can occur and persist over time sets of statistically distinct conditions, that is, microclimates. Microclimates can be found in most places but are most pronounced in topographically dynamic zones such as mountainous areas, islands, and coastal areas (Ellis and Eaton 2021).

Statement of the Problem

Forests influence climate through exchanges of water, carbon dioxide, energy and other chemical species with the atmosphere (Joseph et al. 2004, Song et al. 2014). Forest provides shade which reduces direct sunlight and lowers temperature (Bryant. 1997). The dense canopy of trees blocks a portion of the incoming solar radiation preventing excessive heating. This causes a cooler micro-climate in forest area (Gash and Stewart 1977). If deforestation occurs there is decline in rainfall, subjecting the area to drought. Rainfall can be lost from the area permanent drying occurs and flood regimes of rivers are altered (Day and Megaham 1975).

When deforestation occurs, much of the carbon stored by trees is released back into the atmosphere as co_2 which contributes to climate change (Waring. and Schlesinger 1985). The Intergovernmental Panel on Climate Change (IPCC) has forecasted an increase in the average temperature of the world within the range 1·4–5·8ºC by 2100. Research carried out by four independent institutions analyzed that the decade (2000–2009) was the warmest on record. Since 1750 there has been an observed increase of 31% in the level of atmospheric carbon dioxide (CO_2). Over the 20th century there has been an increase of about 0.6°C in the average surface temperature of the earth and the process had continued since 1861 (Afreen et al. 2012). Since the late 1950s there has been an increase in global temperature in the increases in the lowest 8 kilometers of the atmosphere and in surface temperature have been similar at 0.1°C per decade (Aaron and Matthew 2014).

Deforestation increases surface temperature, excessive emission rates of carbon dioxide, soil degradation and increase in surface runoff resulting in flash floods. Removal of forest cover alters global and regional climate patterns and results in catastrophic rainfall spells followed by prolonged dry periods (Strasser et al. 2014).

The impacts of climate change are devastating in developing countries due to lack of capacity in accordance with the changing climate. Rich countries effectively violate the human rights of thousands of the world's poorest people by excessive exploitation of natural resources. Continuous emission of greenhouse-gases from industrialized nations is resulting in hydro-meteorological events, sea-level rise, and seasonal unpredictability (Yuksel 2014, Adnan et al. 2011). Deforestation has adversely affected the climate pattern and stability in South Asia in the recent years. Asia comprises of about 15% of the global forest area. The impacts of deforestation are far more adverse than in any other part of the world (Pierre et.al. 2011). It is because of the influence of forest cover on the regional hydrological cycle, Asian monsoon pattern, and circulation pattern that effect not only the region but has global impact. Some of these adverse impacts would result in variation in the following:
• Rainfall: There would be an expected decrease in the annual precipitation rate in the region as a result of deforestation. There would be prolonged dry spells followed but short periods of intense rains;
. • Temperature: Forest cover regulates the air and surface temperature by absorbing carbon dioxide, with a decrease in the forest cover there would a significant increase in the temperature of the region. An increase of about 1°C is predicted for the region due to deforestation and reduced rate of evaporative cooling. (Schweikert et al. 2014).

Charney and others (1975) have argued that the increase in surface albedo is the result of removal of vegetation cover and increased albedo causes the rise in atmospheric temperature. Sagan(1979) points out that vegetated surface is usually cooler than bare ground. Forests can increase precipitation level has a long history (Trewartha 1968). The tropical forests with its large leaf surface area hash rate of evapotranspiration amounting to more than 50% of precipitation (Berkmuller 1992). In a global basis, the evapotranspiration from land supplies about 20% of the water vapor to the atmosphere annually (Westall and Stumm. 1980). Half of the precipitation falling in Amazon Basin may be derived from evapotranspiration from the rain forest (Dall'Olio and Vose 1984).

In south- eastern hill region of Bangladesh, deforestation causes significant climatic change (Shaheed and Saleheen2002, Shaheed2007). Once, hill region was dominated by mixed evergreen and deciduous forest (Lewin 1869) He wrote that the maximum summer temperature of that area never exceeds 80^0F (Lewin

1912), variation is not more than 10^0F, cloudiness and drizzling is a common phenomenon of forest clad hills of Chittagong (Hutchinson,1906). But after construction of Kaptai dam, massive deforestation began (Gain 2000) and temperature continued to rise. During the mid1960s, Rangamati recorded a maximum temperature of 34^0 C or 93^0F (Brammer 1966) Following this, in 1997, Rangamati Meteorological Centre recorded a temperature of 42.2^0 C (SRDI 1997). In recent years, the maximum summer temperature (recorded highest- not average) has been risen up to 43^0C) and day-night variation is 16^0-20^0 in deforested zone (unpublished office documents of Bangladesh Meteorological Department-2023). Sojib and Hasan (2023) show deforestation causes increased greenhouse effect in Madhupur Sal forest in Bangladesh. It is also responsible for exposing land to heat and rain. Ruthless deforestation causes enormous ecological hazard in hilly districts. Every year, huge debris accumulates in the beds of Karnaphuli, Sangu, Matamuhuri, Chengi Mynee and other torrents. In rainy season, the inhabitants have been suffering from accelerated flood hazards. The average and maximum temperature of this locality (specially, in CHTS) has been risen abruptly. Crisis of water in dry season (due to disappear of hilly springs) has already been noticed in recent years (Gain 2000). Cutting of natural tree and plantation of exotic species creates harmful situation to hill environment (Gain1998). Plantation of foreign species is not proper replacement (Schendel 2000). Plantations are monoculture and the lack of biodiversity is of concern. They typically have sparse canopies and so do not protect land. They cause air temperature to rise (Marchak 1997). From 2001 -2022 Chittagong lost 10.9 Kha (kilo hectare) of tree cover, equivalent to a10% decrease in tree cover since 2000 and 6.19 mega ton of co_2 emission.

From 2002 to 2022, Chittagong lost 148 ha of humid primary forest, making up 1.4% of its total tree cover loss in the same time period. Total area of humid primary forest in Chittagong decreased by 8.2% in this time period. From 2001 to 2022, Chittagong lost 10.9 kha of tree cover, equivalent to a 10% decrease in tree cover since 2000, and 6.19 Mt of CO_2 emission from 2000 to 2020. Chittagong experienced a net change of 21.3 kha (12%) in tree cover ((https:// www.globalforestwatch.org).

Deforestation and forest land grabbing is very evident, from the Kaptai Range's Bangchori to the Baluchari area. There, rows of Segun(teak) trees and gardens with fruits trees like mango, jackfruit etc. But those gardens can't be called forests (Mahmud and Chakma. 2022). In recent years, there has been a decrease in overall rainy season precipitation with rising temperatures during the summer (Chakma 2023).

Objective

Explore the microclimatic variation in forest clad and deforested hill ridges.

Hypothesis

Monoculture of exotic species and destruction of natural forest cause excessive heating and low precipitation in hill region.

Methodology

In low elevated hilly area, forest cover acts as a key control of local climate' – keeping this fact in mind, the nature of field investigation has been formulated on the basis of following criteria
-Climatic condition of dense indigenous forest;
-Climatic condition of depleted forest
-Climatic condition of extensive monoculture
To measure the meteorological condition of above places, highest temperature and variation of temperature of different vegetation have been

recorded from hilltop and valley area. Temperature has been recorded in a certain time and in a certain location. Temperature of different land coverings (natural woodland forest, natural bushes, depleted lands, teak garden and orchard) has been recorded at same time. The average humidity of different vegetated lands has been measured by digital hygrometer. The participants have been engaged in this purpose.

Different participatory sessions have been arranged to know the present and past climatic condition. Participants have been asked for temperature and precipitation status of the locality and their previous condition. Very old people of a locality and experienced officials or experts who gathered vast knowledge on the study area have been treated as key individuals. Their information is very important to design the actual problems after deforestation. The information of forest rainfall has been collected from key individuals and then confirmed it through group meeting.

Different statistical techniques have been adopted to calculate actual micro climatic differences. Paired sample tests have been done to measure the differences in temperature and humidity between forest and different depleted lands.

Regressions have been done to measure the influence of endemic tree in air temperature and humidity. In this purpose data have been collected adopting a special process. At first, density of tree of a certain area has been counted adopting transect and then record temperature and humidity.

Dependency of different forms of precipitation and condensation like forest rain, regular cloudiness and total rainy day has also been measured through regression analysis.

Long-term travel and data collection have been done in the Chittagong region to observe mixed hill forests and environmental changes after deforestation. Last data of 2023 was taken in the study area to monitor tree density and vegetation cover type. The table below indicates the objectives, data types, method and techniques at a glance.

Objective	Data involve	Method/ Technique
Explore the microclimatic variation in forest clad and deforested hill ridges	- highest temperature and variation of temperature - average humidity - local and *forest rainfall *Present research investigated the existence of a rare climatic phenomenon- forest rainfall or drizzling due to over transpiration from dense vegetation.	**RGA (Rapid Geographical Appraisal)** -Temperature recording using of thermometer -Humidity recording using of hygrometer -Group Discussion -***PRA** Time Trend Analysis -survey of individual's opinion --Bi-variate correlation, Regression analysis and Paired Sample Test (as statistical analysis * Participatory Reflection and Action

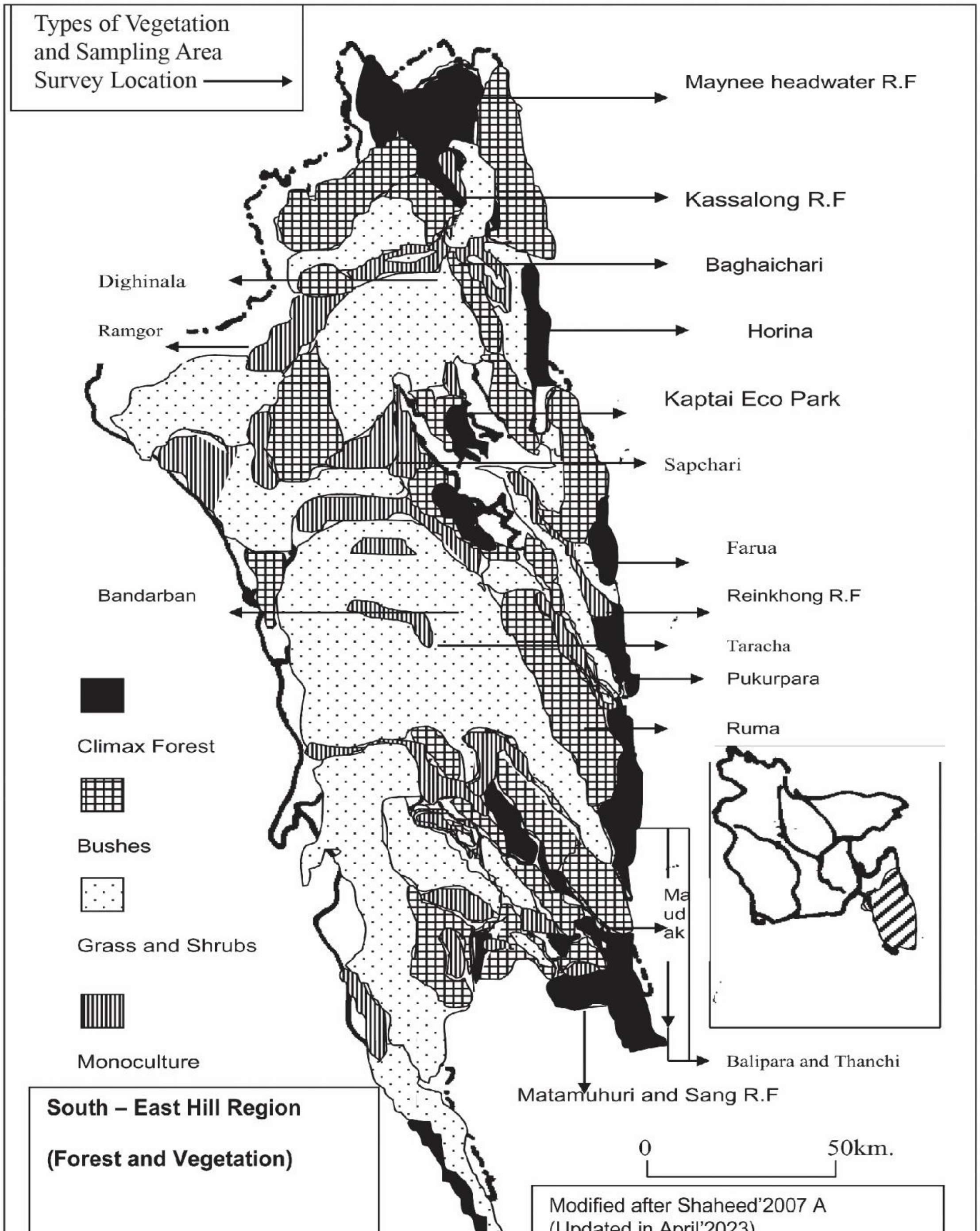


figure 1: Locations of Micro-Climatic Study

Availability of Secondary Data and Relevance to this Research

The research is mainly done on the basis of field level data. Secondary data have been collected from published and unpublished documents of Bangladesh Meteorological Department to justify the field data.

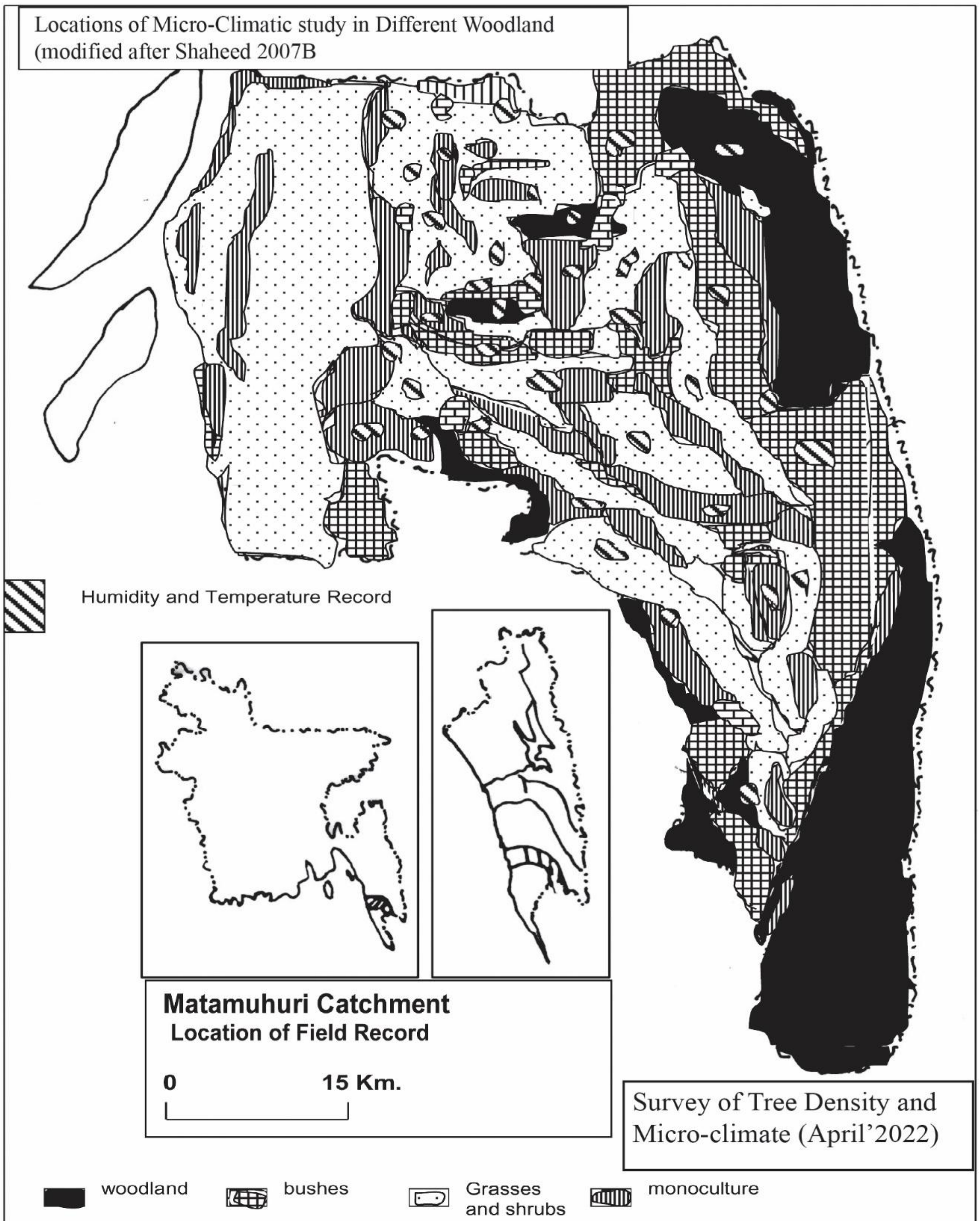


figure 2: Temparature and Humidity Record in different Woodlands in Matamuhuri Catchment

Study Area: The Chittagong Hill Region occupy about 19,000 square km. (both two greater districts of Chittagong and Chittagong Hill Tracts). Obviously, it is a vast area for a researcher to survey adequately. In this case, selection of sampling area is essential in where all or maximum categories of vegetation cover are found. Different sampling locations are shown in figure1 and figure2

Result of Temperature and Humidity Record

Table 1 shows the highest temperature and temperature variation in different places of study area. Table 2-3 follows 1 for pair sample test between data of natural forest and different types of deforested lands. Table 4 expresses average humidity and table 5 explains pair differences of humidity data.

Table 1 also shows the temperature of different land covering in where difference between different land coverings is clear. The mean highest temperature in natural forest is 27.94^{0}c recorded and temperature variation is 6.2^{0}c. But in teak garden, this feature is 36.39^{0}c and 10.59^{0}c, in orchard 33.98^{0}c and 9.33^{0}c, in depleted forest 35.6^{0}c and 9.33^{0}c and in bushy area 31.15^{0}c and 7.45^{0}c. The variation of temperature in different land coverings is significant.

Table 1: Highest Temperature and Variation of Temperature in Study Area

Station	Natural climax forest nc ^{0}C		Depleted land(dl) ^{0}C		Bushy area(bs) ^{0}C		Teak Monoculture tm ^{0}C		Orchard od ^{0}C	
	[1]HT	[2]VT	HT	VT	HT	VT	HT	VT	HT	VT
1	26.0	06.2	36.0	10.0	30.0	7.7	38.0	11.0	33.6	9.6
2	28.0	07.0	32.0	9.2	30.2	7.0	37.5	10.5	34.8	9.5
3	26.8	07.0	33.4	9.5	31.8	7.5	38.0	10.6	32.9	9.4
4	29.0	06.5	34.9	9.0	30.4	7.5	39.0	10.2	35.7	9.5
5	28.6	06.4	34.7	9.5	30.6	7.0	39.0	10.8	34.7	9.4
6	30.0	06.5	44.0	9.7	30.6	7.5	36.0	11.5	33.4	9.2
7	27.8	06.3	35.7	10.5	32.5	7.5	35.6	11.0	33.0	9.0
8	27.6	06.8	35.7	8.2	31.8	7.4	32.0	10.2	34.8	9.0
9	28.0	06.8	36.3	9.5	32.0	7.2	34.4	10.1	34.5	9.4
10	28.9	6.6	37.0	8.5	30.9	7.8	34.2	10.0	33.9	9.2
11	28.0	06.6	35.0	9.0	31.8	7.8	35.6	10.6	32.5	9.4
Mean	27.94	6.2	35.64	9.33	31.15	7.45	36.39	10.59	33.98	9.33

[note: HT means highest temperature VT means variation of temperature]

Table 2: Paired Samples Test- Highest Temperature

Paired Differences nc- dl, nc-bs, nc-tm, nc-am					t	df	Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-7.81818	.2.58334	.77891	-9.55369	-6.08267	-10.037	10	.000
-3.08182	1.47839	.44575	-4.07501	-2.08862	-6.914	10	.000
-8.23636	.2.54255	.76661	-9.94447	-6.52826	-10.744	10	.000
-5.91818	.1.26398	.38110	-6.76733	-5.06903	-15.529	10	.000

Table 3: Paired Samples Test- Variation of Temperature

Paired Differences nc- dl, nc-bs, nc-tm, nc-am					t	df	Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-2.71818	.81341	.24525	-3.26464	-2.17173	-11.083	10	.000
-.83636	.44782	.13502	-1.13722	-.53551	-6.194	10	.000
-.83636	.44782	.13502	-1.13722	-.53551	-6.194	10	.000
-3.98182	.63217	.19061	-4.40651	-3.55712	-20.890	10	.000
-2.71818	.32808	.09892	-2.93859	-2.49777	-27.479		

Above two tables show the actual difference in highest temperature and temperature variation between forest clad and other lands (bushy area, thin grass and shrub, teak monoculture and orchard) in hilltops. Mean difference and t values are negative in every case that means highest temperature in other land coverings is really higher than forestland. The level of significance is .000 in every case. In case of highest temperature standard error varies from .381 -.778 and standard deviation .12- 1.4. In case of temperature variation standard error varies from .098 -.245 and standard deviation .32-.81. So, data fit is good. The pair difference is highest in teak monoculture and lowest in natural bushes that means teak causes maximum temperature rise in hill districts. Orchard and excessive depleted lands also show high difference of t value.

Table 4 Average Humidity in Study Area

Station	Natural climax forest	Depleted land (very thin shrub or grass	Bushy area	Teak Monocultur e	Orchard
	Humidity %	Humidity %	Humidity %	Humidity %	Humidity %
1	78	53	67	50	51
2	81	51	65	48	53
3	80	53	68	48	49
4	82	55	68	52	50
5	78	55	69	51	52
6	76	52	67	50	53
7	83	56	68	51	52
8	77	58	66	49	51
9	80	56	66	52	49
10	81	54	71	53	49
11	79	54	70	49	52
mean	79.55	54.27	67.73	50.27	51

Table 5: Paired Samples Test- Average Humidity

Paired Differences1)A-B,2)A-C,3)A-D,4)A-E					t	df	Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
1)25.2273	2.86674	.86435	23.34683	27.19863	29.239	10	.000
2)11.81813	2.56196	.77246	10.09703	13.53933	15.299	10	.000
3)29.27273	2.28433	.68875	27.73809	30.80736	42.501	10	.000
4)28.54545	3.01210	.90818	26.52190	30.56901	31.431	10	.000

Table 5 shows the actual difference in average humidity between forest clad and other lands (bushy area, thin grass and shrub, teak monoculture and orchard) in hilltops. Mean difference and t values are positive in every case that means average humidity in other land coverings is really lower than forestland. The level of significance is .000 in every case, standard error varies from .68-.90 and *standard deviation 2.22 -3.0 (in this test standard deviation indicates the pair difference of standard deviation). In case of teak monoculture, the variation is highest that means teak absorbs water vapor too much. The pair difference is lowest in case of natural bushes.

4: Density of Tree, Temperature and Humidity Above tables can prove it- 'natural tree has a great role in modifying temperature'. Table 6-7 shows the relation of tree density and variation of temperature.

Table 6: Density of Natural Tree and Temperature Variation (excluding monoculture)

Density of natural tree from different places (per sq.km.)	STATIONS																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	3	7	2	0.6	0.12	0.74	13	19	17	49	123	54	31	33	44	0.66	0.30	0.46	0.05	0.03	0.70
Temperature variation(^{0}c)	11	10.8	11	12.6	14	12.5	10.4	10.1	10.2	6.0	3.5	5.8	6.7	6.2	6.3	12.4	13	12.8	19.9	20.3	19.7

[temperature has been recorded from Matamuhuri Catchment area in April'2022]

Table 6 shows that variation of temperature decreases with the increase of tree density. Variation of temperature is 20.3^{0}c in where tree density is 0.03 per square kilometer but it is only 3.5^{0}c in where tree density is 123 per square kilometer.

Table 7: Density of Natural Tree and Maximum Temperature (excluding monoculture)

Density of natural tree from different places (per sq.km.)	STATIONS																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	3	7	2	0.6	0.12	0.74	13	19	17	49	123	54	31	33	44	0.66	0.30	0.46	0.05	0.03	0.70
maximujm temperatur(^{0}c)	32.0	32.0	32.0	34.6	34.4	34.0	31.3	31.3	31.3	27.5	24.5	27.4	28.4	28.4	27.5	34.2	34.4	34.4	36.8	36.8	34.0

[temperature has been recorded from Matamuhuri Catchment area in April'2022]

Table 7represents maximum temperature in natural woodland is lower than that of thin woodland. Dense woodland (tree density 123 per sq.km) represents 24.5^{0}c maximum temperature whereas depleted lands (tree density 0.03 per sq.km) represent 36.8^{0}c at same time. Table 7shows that the maximum temperature is 36.8^{0}c in where tree density is .03 -.05 but it is only 24.5^{0}c in where tree density is 123.

So, from field data, it is clear, destruction of natural forest obviously causes the microclimatic change for rise in temperature and variation of temperature. To establish the matter strongly correlation and regression analysis have been performed after data set up.

7a Bi- Variant Correlations for tree density-temperature variation

		VAR00001	VAR00002
VAR00001(tree)	Pearson Correlation	1	-.728(**)
	Sig. (1-tailed)	.	.000
	N	21	21
VAR00002(temperature variation)	Pearson Correlation	-.728(**)	1
	Sig. (1-tailed)	.000	.
	N	21	21

** Correlation is significant at the 0.01 level (1-tailed).

Correlation analysis shows very strong positive relation (1) between tree and temperature variation but negative relation between temperature variation and tree that means tree reduces temperature in general case but temperature reduces tree.

7b Bi- Variant Correlations for tree density-maximum temperature

		VAR00001	VAR00002
VAR00001	Pearson Correlation	1	-.876(**)
	Sig. (2-tailed)	.	.000
	N	21	21
VAR00002	Pearson Correlation	-.876(**)	1
	Sig. (2-tailed)	.000	.
	N	21	21

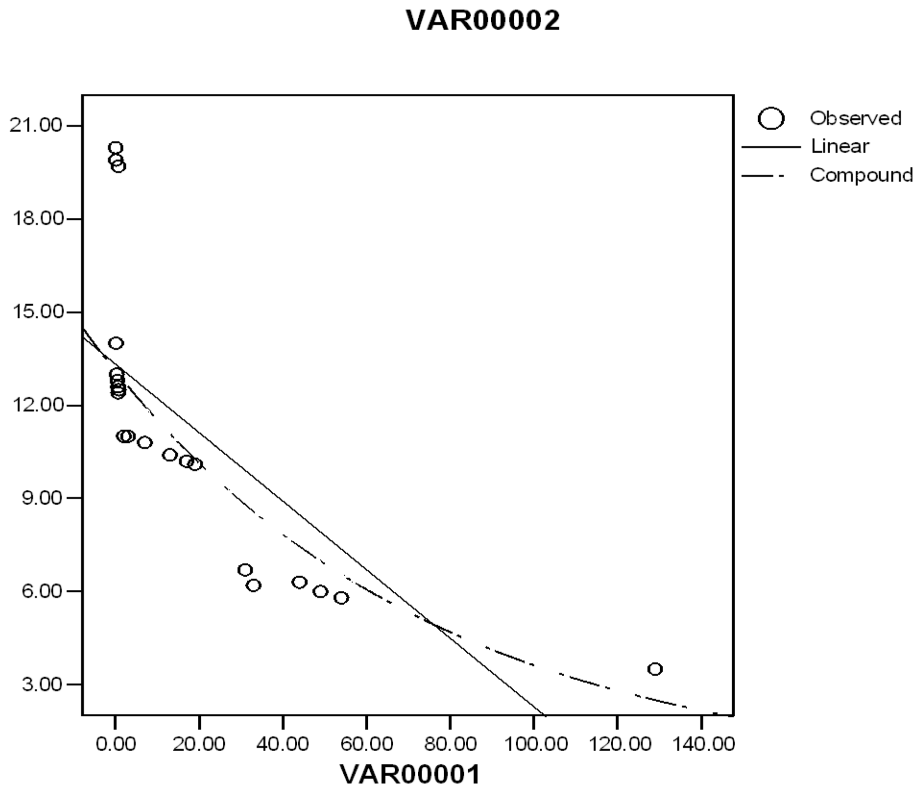
** Correlation is significant at the 0.01 level (2-tailed).

Correlation analysis shows very strong positive relation (1) between tree and maximum temperature but negative relation between temperature variation and tree that means tree reduces temperature in general case but temperature reduces tree. In both cases, significance level is .000 (where it is significant up to 0.01).
The following regression analyses explain it adequately.

7c Regression fortree density-temperature variation

Independent: VAR00001(tree)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1
VAR00002	LIN	.530	19	21.46	.000	13.3275	-.1104
VAR00002	COM	.765	19	61.73	.000	13.1038	.9872



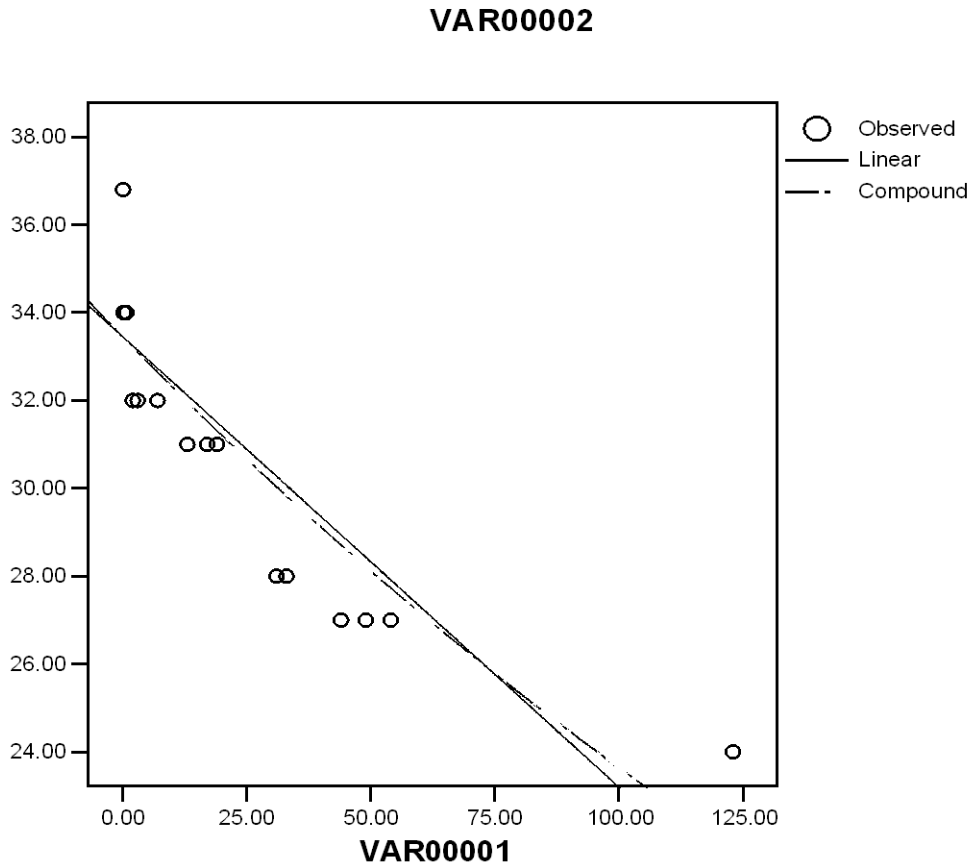
The linear regression analysis shows that 53.0% variation in temperature is explained by tree density, fixed temperature level is 13.3275^{0}c and temperature variation is 0.1104^{0}c reduced for per unit tree.

But compound curve analysis shows that 76.5% variation in temperature is explained by tree density, fixed temperature level is 13.1038^{0}c and temperature variation is 0.9872^{0}c excessive for per unit tree.

7d. Regression for tree density- maximum temperature

Independent: VAR00001(tree)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1
VAR00002	LIN	.767	19	62.72	.000	33.4505	-.1025
VAR00002	COM	.813	19	82.41	.000	33.4450	.9965



The linear regression analysis shows that 76.7.0% temperature is explained by tree density, fixed temperature level is 33.45^{0}c and temperature is 0.1025^{0}c reduced for per unit tree.But compound curve analysis shows that 81.3% temperature is explained by tree density, fixed temperature level is 33.445^{0}c and temperature variation is 0.9965^{0}c excessive for per unit tree.

Compound curve expresses exceptional situation. In this case, the curve predicts different exceptional conditions of nature. As for example, teak monoculture causes rise in temperature as well as excessive variation in temperature.

Above two regressions show .000 significance level and high value of F. Thus the test is very highly significant.

[b_0= fixed value of the dependent variable, i.e., the value of depended variable for zero value of independent variable. b_1=slope of regression line for independent variable, i.e., amount change in dependent variable due to per unit change in independent variable.]

Table 8: Density of Natural Tree and Average Humidity (excluding monoculture)

Density of natural tree from different places (per sq.km.)	STATIONS																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	3	7	2	0.6	0.12	0.74	13	19	17	49	123	54	31	33	44	0.66	0.30	0.46	0.05	0.03	0.70
Average humidity	54	54.2	54	52.4	49.3	51	54	54.2	54	58	84	61	55	54	55	49.5	49	49	48	48	49

[humidity has been recorded from Matamuhuri Catchment of study area]

8a. Bi- Variant Correlations for tree density-average humidity

		VAR00001	VAR00002
VAR00001(tree)	Pearson Correlation	1	.940(**)
	Sig. (2-tailed)	.	.000
	N	21	21
VAR00002 (humidity)	Pearson Correlation	.940(**)	1
	Sig. (2-tailed)	.000	.
	N	21	21

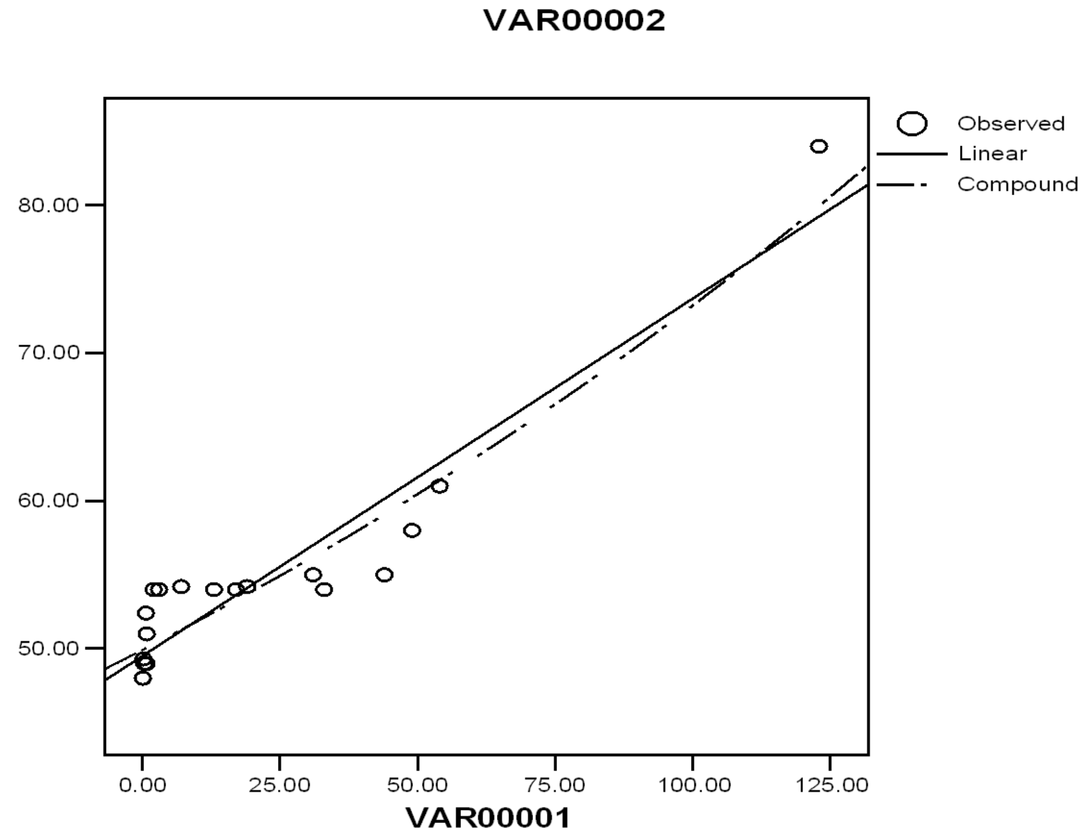
** Correlation is significant at the 0.01 level (2-tailed).

Correlation between tree and average humidity is 1 and it is .940 between humidity and tree. In both cases significance level is .000, in where, the test is significant within 0.01 level. So, the test is very highly acceptable.

8b Regression for tree density-average humidity

Independent: VAR00001(tree)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1
VAR00002	LIN	.884	19	145.13	.000	49.5116	.2417
VAR00002	COM	.888	19	150.13	.000	49.9202	1.0038



The linear regression analysis shows that 88.4% humidity is explained by tree density, fixed humidity level is 49.511% and humidity is .2417% increased for per unit tree.

Compound curve analysis shows that 88.8% humidity is explained by tree density, fixed humidity level is 49.9202% and humidity is 1.0038% increased for per unit tree.

Regression shows .000 significance level and high value of F (145.13,150.13). Thus, the test is very highly significant.

Deforestation and Change in Precipitation

Table 9 and 10 show that rainfall of study area is decreased but forest clad zone represents better situation. Table 11shows the relationship between forest and precipitation. Obviously, deforestation causes negative impact on regular precipitation.

Table 12 shows that in 1940s and 1950s the whole hill region was influenced by forest rainfall (drizzling from over transpiration and cloudiness). From 1960s it has been disappearing rapidly. In 2000s, it was traced only Sangu reserved forest and Pukurpara but decreased too much reportedly. Actually, small area of forestland cannot create this situation. A chain of extensive forestland can create rainfall due to over transpiration. Reduction of forestland in this case must be responsible for decreased rainfall.

Table 9. Result of group discussion on changes in precipitation after deforestation

Stations	Result of group discussion on precipitation	Comment
1	precipitation is decreased slightly, intensity of regular forest rainfall is decreased too much, monsoon rain is almost unchanged	maximum (<80%) area is forest covered but nearby forest region has been drastically reduced
2	precipitation is decreased significantly; forest rainfall is almost nil due to massive destruction of nearby forestlands	the locality is covered by scattered natural woodland or bushes but nearby forest region has been lavishly destroyed
3	precipitation is decreased in context of 1960-1980s.	the locality is dominated by natural forest
4	precipitation is decreased due to destruction of forest in surrounding area	natural woodlands dominate the zone
5	precipitation is decreased	natural climax forest influences the hilly area
6	precipitation is decreased	natural woodland forest creates classical hill forest climate
7	precipitation is decreased	the area is dominated by dense natural bushes with scattered trees
8	precipitation is decreased	the area is dominated by dense natural woodland and plantation
9	precipitation is decreased	the area is dominated by dense natural forest
10	precipitation is decreased	the area is dominated by dense natural woodland and plantation
11	precipitation is decreased	the area is dominated by very dense natural bush with scattered trees

[Show in fig.1.1Sangu reserved Forest, 2. Balipara,3.Matamuhuri reserved forest 4.Ruma 5.Pukurpara 6.Maudak 7. Taracha 8. Kaptai 8.Horina 9. Kasssalong reserved forest 10.Dighinala 11.Baghaichari]

Table 10: Result of in-depth survey on changes in precipitation after deforestation

Stations	Result of survey								Comment
	decrease in rainfall				increase in rainfall				
	Very high	high	medium	low	Very high	high	medium	low	
1			13	87	nrp	nrp	nrp	nrp	
2			32	68	nrp	nrp	nrp	nrp	
3			30	70	nrp	nrp	nrp	nrp	
4		4	28	68	nrp	nrp	nrp	nrp	old aged people (50+) reply high decrease
5		2	33	65	nrp	nrp	nrp	nrp	-do-
6		2	35	63	nrp	nrp	nrp	nrp	-do-
7		3	31	66	nrp	nrp	nrp	nrp	-do-
8		6	34	40	nrp	nrp	nrp	nrp	-do-
9		1	24	75	nrp	nrp	nrp	nrp	-do-
10		4	34	62	nrp	nrp	nrp	nrp	-do-
11		7	36	57	nrp	nrp	nrp	nrp	-do-

Note: nrp represents no reply

Table 11: Regular cloudiness, drizzling and shower (December-May)

Places	Thin cloudiness (total day)	Drizzling (total day)	Shower (total day)	Proportion of forest (%)
Sang R.F	182	236	120	87
kuruppata	150	166	60	62
Lemupalong	120	121	42	58
Ruma	80	87	36	43
Taracha	25	15	6	6
Baghaichari	25	12	6	1
Balipara	25	12	8	2
Horinjhiri	40	30	16	2
Alikadam	42	21	31	17
Maynee R.F	160	120	32	80
Horina	58	30	11	23

Note: The table has been prepared through PRA Session and PRA Mapping

Table 12 Visibility of forest **drizzling in different decades**

places	visibility of forest rainfall								
	1940	1950	1960	1970	1980	1990	1995	2002	2023
Farua	viz.	viz.	vf	nv	nv	nv	nv	nv	nv
Sapchari	viz.	viz.	viz.	nv	nv	nv	nv	nv	nv
Thanchi	viz.	viz.	viz.	nv	nv	nv	nv	nv	nv
Ruma	viz.	viz.	viz.	viz.	vf	nv	nv	nv	nv
Modok	viz.	viz.	viz.	viz.	viz.	nv	nv	nv	nv
Dighinala	viz.	viz.	viz.	nv	nv	nv	nv	nv	nv
Sangu rf	viz.	viz.	viz.	viz.	nv	nv	nv	nv	nv
Horina*	viz.	viz.	nv	nv	nv	nv	nv	nv	nv
Kasalong rf	viz.	viz.	viz.	viz.	viz.	viz.	vf	nv	nv
Pukurpara	viz.	viz.	viz.	viz.	viz.	vf	nv	nv	nv
Matamuhuri rf	viz.	viz.	viz.	viz.	viz.	vf	vf	nv	nv

note: viz. represents visible, vf represents very few, R.F represents reserved forest, nv represents not visible (modified after Shaheed,2007)

The rare climatic phenomenon of hill forest has been identified from key individuals interview that is forest rainfall (drizzling for transpiration) and cloudiness over forest cover in comparatively less compact forest. The phenomenon was present in depleted places when they were covered by dense forest.

Table 11 represents total day of cloudiness, drizzling, and shower in dry season in different hilly area. The table also shows the proportion of forest in those stations and adjoining area. From this table correlation between forest cover and different forms precipitation can be calculated. Later, regression analysis has also been done adopting SPSS software.

a: Correlations (forest- regular cloudiness)

		VAR00004	VAR00001
VAR00004 (forest)	Pearson Correlation	1	.984(**)
	Sig. (2-tailed)	.	.000
	N	11	11
VAR00001(cloudiness)	Pearson Correlation	.984(**)	1
	Sig. (2-tailed)	.000	.
	N	11	11

** Correlation is significant at the 0.01 level

b.Correlations (forest- forest rainfall)

		VAR00004	VAR00002
VAR00004 (forest)	Pearson Correlation	1	.904(**)
	Sig. (2-tailed)	.	.000
	N	11	11
VAR00002 (forest rain)	Pearson Correlation	.904(**)	1
	Sig. (2-tailed)	.000	.
	N	11	11

** Correlation is significant at the 0.01 level

c: Correlations- forest-shower

		VAR00004	VAR00003
VAR00004(forest)	Pearson Correlation	1	.805(**)
	Sig. (2-tailed)	.	.003
	N	11	11
VAR00003(rainy day)	Pearson Correlation	.805(**)	1
	Sig. (2-tailed)	.003	.
	N	11	11

** Correlation is significant at the 0.01 level

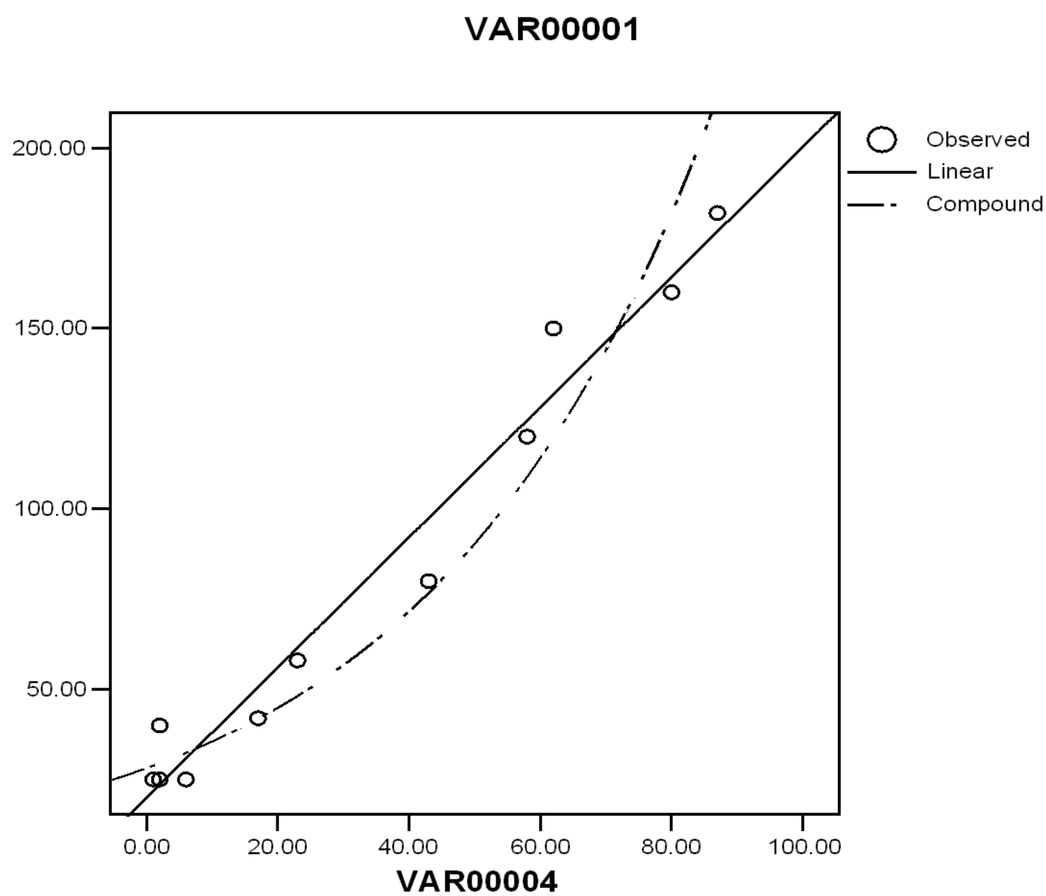
Above three tables express strong correlation between forest and regular cloudiness, forest and regular drizzling or forest rainfall and forest and shower. The results are .984, .90 and .805. Regressions make them more perfect.

d: Regressions for Forest-Regular Precipitation

1. Forest and Regular Cloudiness

Independent: VAR00004(forest)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1
VAR00001	LIN	.969	9	282.66	.000	20.0273	1.8024
VAR00001	COM	.944	9	150.47	.000	28.1691	1.0236

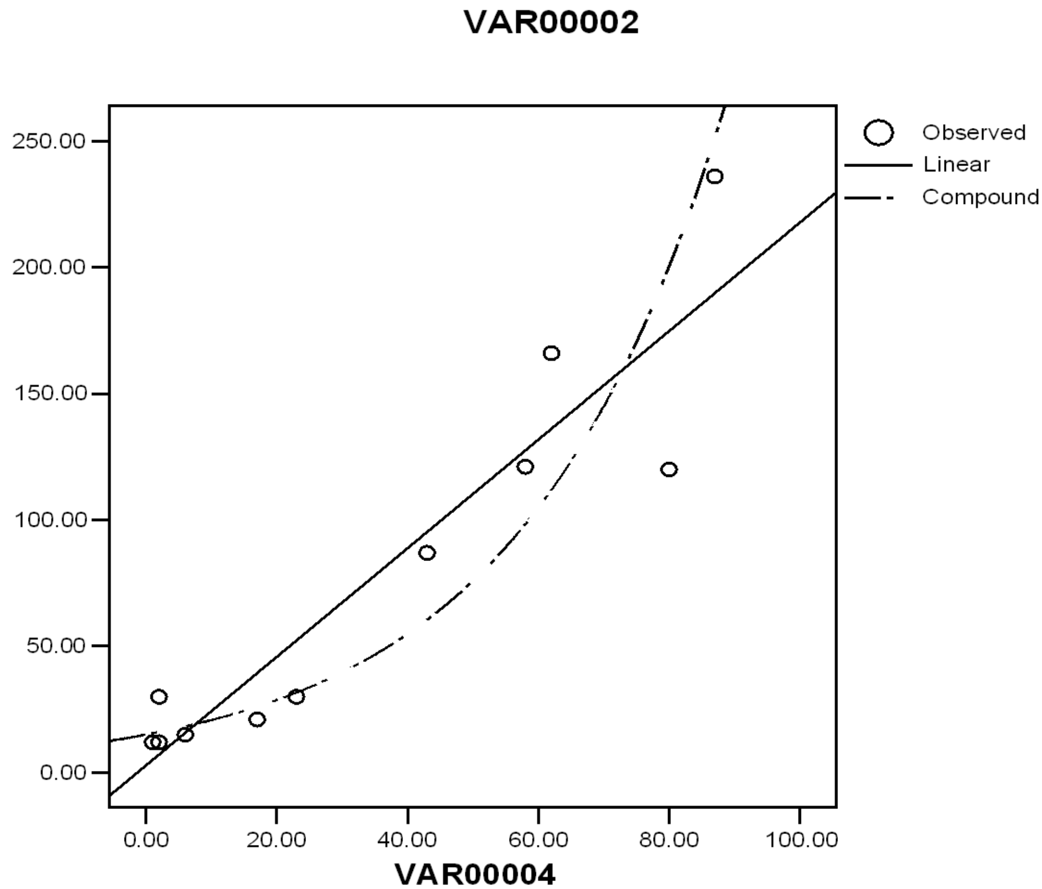


The R^2 value expresses strong relationship between regular cloudiness and forest cover.96.9% of dependent variable is explained by the independent variable. The real explanation is that in normal situation, forest cover causes the prolongment of total cloudy day or dense forest causes regular cloudiness. For compound curve, the percentage is 94.4% - so it is sure, forest cover is responsible for increase of cloudiness.

2. Forest and Forest Rain (regular drizzling)

Independent: VAR00004(forest)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1
VAR00002	LIN	.867	9	58.71	.000	2.8495	2.1487
VAR00002	COM	.901	9	82.04	.000	15.0414	1.0329

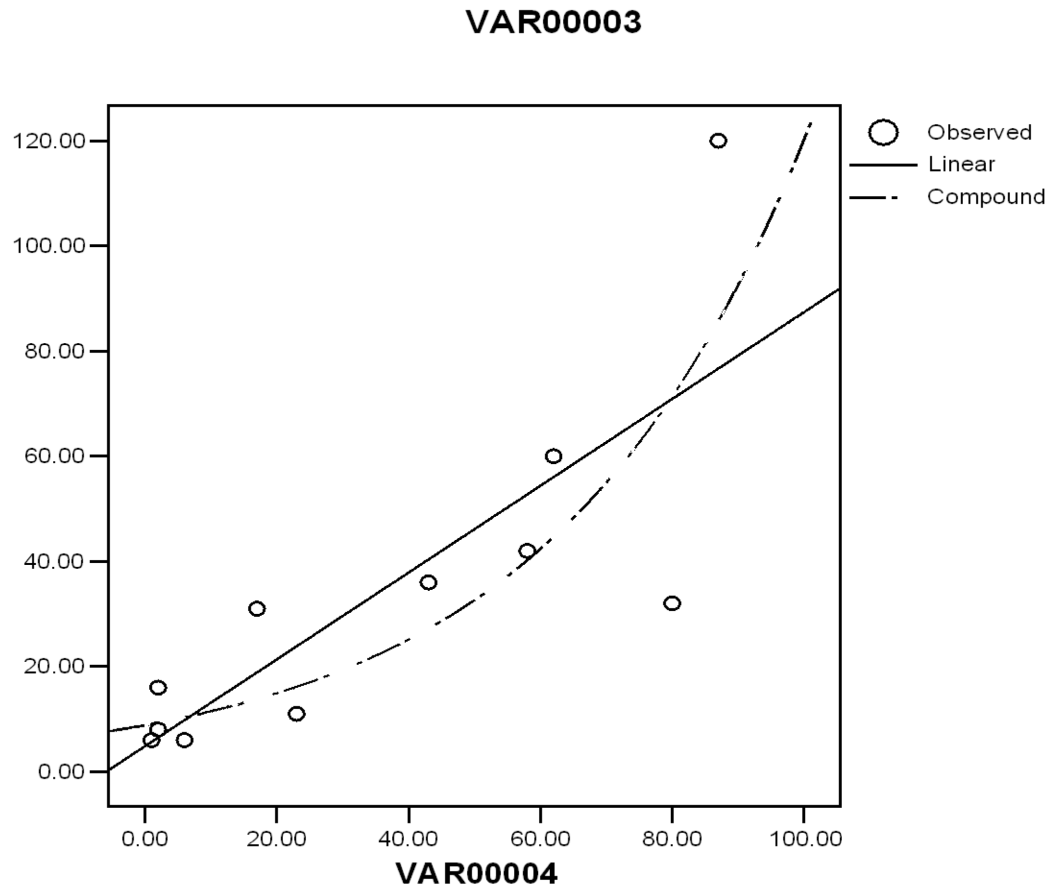


The above regression curve also expresses positive correlation between dependent and independent variable. For linear regression, 86.7% of dependent variable is explained by independent variable. For compound curve, the percentage is 90.1%. Obviously, forest cover is a key factor for regular drizzling.

3. Forest and Total Rainy Day (including forest rain)

Independent: VAR00004(forest)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1
VAR00003	LIN	.648	9	16.57	.003	4.8586	.8256
VAR00003	COM	.743	9	26.05	.001	8.8626	1.0264



The above linear regression curve shows very positive relationship between forest cover and total day of shower. The R^2 value is .648 that means about 65% of dependent variable is explained by independent variable. in normal situation. For compound curve, the percentage is 74.30. Obviously, forest cover causes increase of total rainy day.

The significance level of above three regressions is .000 and value of F is high – so test is highly significant in true sense.

Table 13: Diurnal Temperature(^{0}c) in different Vegetation Cover and Terrain (April,2023)

Time	Teak Garden (Hill top)-A	Teak Garden (narrow valley)-B	Natural Woodland(Hill top)-C	Natural Woodland(narrow valley)-D	Bushes and Grass(Hill top)-E	Bushes and Grass(narrow valley)-F	
6 am	28	21	20	18	28	20	
9 am	32	23	22	20	32	23	
12 am	38	26	26	21	36	25	
2 pm	40	28	27	22	37	26	
6pm	36	24	24	20	33	24	
mean	34.8	24.4	23.8	20.2	33.2	23.6	

Location: Rampahar - Sitapahar reserve forest and adjacent area, Kaptai

Table 13 shows temperature record of different time and vegetation cover in a particular area. Temperature across different vegetation covers and topography are observed from the mean temperature of teak garden, natural woodland forest and ground cover of shrubs and grasses in Kaptai Rampahar and Sitapahar reserve forest and adjacent areas in the hilltops and narrow valleys. It has relatively low temperature in natural woodland forest. Mean differences are significant.

Discussion Summary

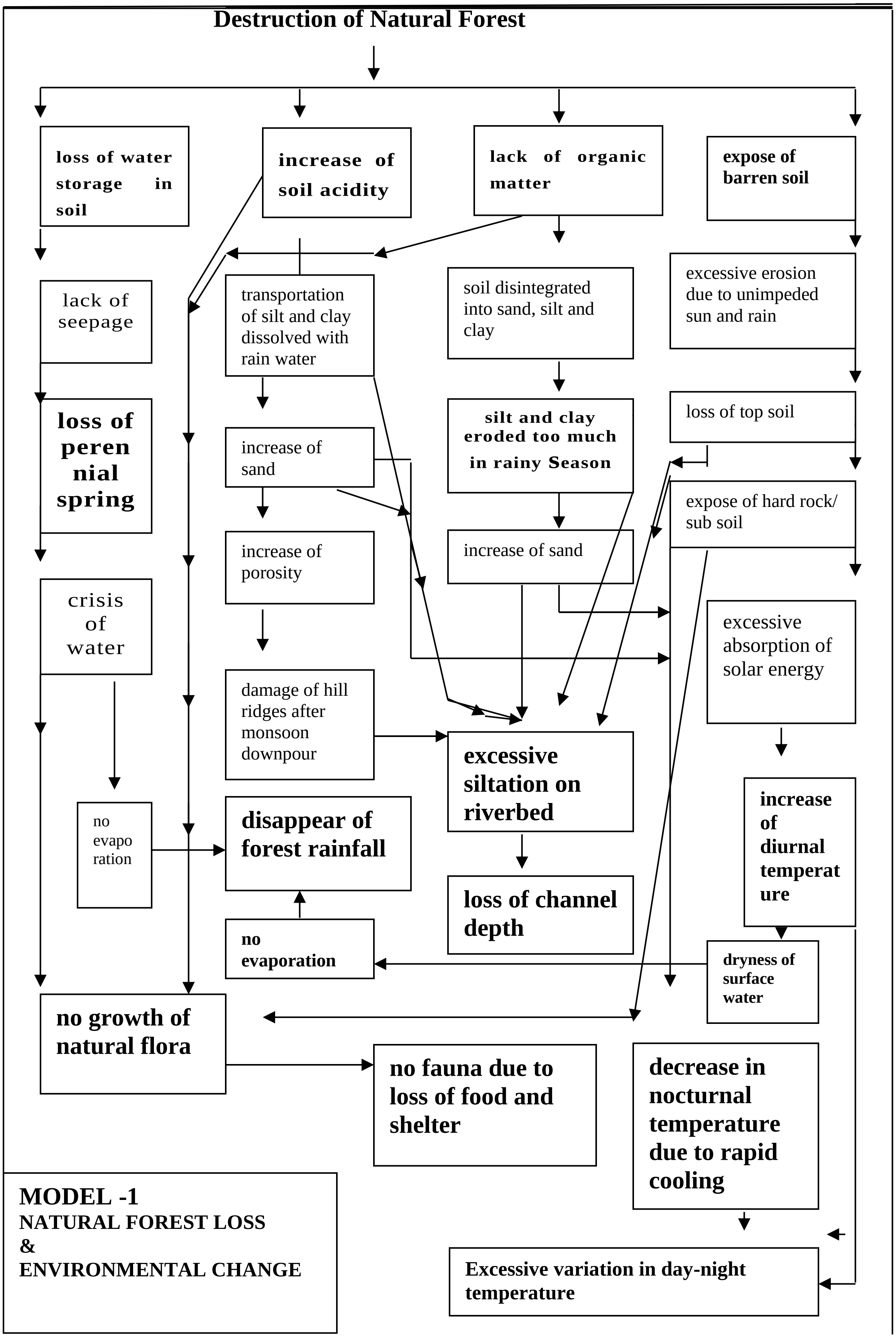
i. Average highest temperature in natural forest is too low in context of depleted land or monocultures. Temperature record shows the sharp difference between natural forest and depleted lands (table 1). But it is interesting that temperature in teak garden is higher than that of normal depleted land. Highest temperature in natural forest varies from 28-30^{0}c whereas it is 40-46^{0}c in depleted land or monocultures. The highest temperature variation and maximum highest temperature are recorded from different teak gardens.
ii. Variation of temperature is also very high in depleted land or monocultures. In natural forest it varies from 3.6-7.5^{0}c whereas it is 18-22^{0}c in depleted land or monocultures (table 1) Table 2-3 shows mean difference and t value. They show clear difference between temperature of natural forest and degraded lands (totally depleted lands and monocultures like teak and orchard). The mean difference between natural forest and teak is highest –that means teak causes excessive temperature rise in a landmass.
iii. Table 4 -5 shows the average humidity of different vegetation and the pair differences. They show that the average humidity is higher in natural forest area than depleted land and monocultures. The humidity is decreased too much in teak and orchard dominated lands.

iv. Table 6-.7 explains effect of tree density on diurnal temperature. Temperature decreases with increase of density of indigenous tree. The correlation and regression analysis ensure the reality very strongly. Regression curves predict decrease of temperature with per unit tree.

v. Table 8 shows the tree density and humidity. The regression explains rise in average humidity with per unit tree.
vi. Table 9 -12 represents precipitation status in forest clad and deforested lands. Table 11 shows strong correlation between forest and local precipitation like forest rain, daily cloudiness and total rainy day of a year. The regression curves show that forest cover causes local regular drizzling, increased rainy day and cloudiness.
vii. Table 13 represents differences in temperature in different vegetation cover and terrain feature in a definite time. Individual records and average show natural woodland forest is cooler than that of deforested ground of shrub and grass. The teak garden is hotter than deforested ground of shrub and grass. It is also hotter than that of natural woodland.

Conclusion and remark:

Above discussion shows the micro climatic differences between natural forest and depleted land or monocultures. Natural forest shows low temperature and high percentage of humidity. In some places it represents forest rain. But due to loss of canopy depleted forest represents high temperature and low humidity. The regression lines show that per unit tree reduces 0.1025^{0}c temperature and increases 1.0038% humidity. The climatic data of SCWM weather station shows


Destruction of Natural Forest
loss of water storage in soil
increase of soil acidity
lack of organic matter
expose of barren soil
lack of seepage
transportation of silt and clay dissolved with rain water
soil disintegrated into sand, silt and clay
excessive erosion due to unimpeded sun and rain
loss of perennial spring
increase of sand
silt and clay eroded too much in rainy Season
loss of top soil
expose of hard rock/ sub soil
increase of porosity
increase of sand
crisis of water
excessive absorption of solar energy
damage of hill ridges after monsoon downpour
excessive siltation on riverbed
increase of diurnal temperature
no evapo ration
disappear of forest rainfall
loss of channel depth
no evaporation
dryness of surface water
no growth of natural flora
no fauna due to loss of food and shelter
decrease in nocturnal temperature due to rapid cooling
MODEL -1
NATURAL FOREST LOSS
&
ENVIRONMENTAL CHANGE
Excessive variation in day-night temperature

that average day-night temperature variation of Bandarban is about 16^0c. The highest average temperature in hotter months is 35.5-39^0c.The highest temperature recorded in Rangamati weather station is 42.5^0c.But once, the figures were 3^0-4^0c (temperature variation) and 25^0-$^{-}26^0$c (old records). The field data from different places of depleted forests shows more degradable situation. 42^0-44^0 highest temperature and 16-22^0c day-night temperature variation is not the feature of tropical monsoon climate (appendix -1&2).
The tropical dry climates of world represent such picture. This category falls into Keopen's BWh category. In this condition, the day-night temperature variation is generally 15^0-25^0C (Trewartha 1980). In tropical monsoon climatic, the day- right temperature variation is generally not more than 5^0C(Barry and Chorely 1968). In this respect, it is not doubt to say, massive deforestation causes significant climatic change in study area. It may not be converted into desert due to monsoon but desert like dry climate has already been traced.The experts have called Bandarban as 'Green Desert'(Gain1997). Model-1 adequately explains the relationship between destruction of natural forest cover and decrease in humidity and temperature rise. Thus, after data analysis and discussion, the fact is revealed that '<u>Destruction of natural forest and creation of monocultures cause excessive rise in temperature and decrease in different form of regular precipitation.'</u>

Trust worth of Research

Different microclimate in different vegetation cover is observed in various places of world. It depends on transpiration capacity of vegetation cover of that locality. The following study by Whtmore can be presented in favor of the practical utility of the present study.

Table 14: Microclimates of open, canopy gap and closed forest compared (Sabah, Malayasia)

Percent sky visible		open	Big gap	Small gap	closed forest
Aerial microclimate		74	31	10	6
Temperature: Maximum		30	38	34.5	28.5
Minimum		22.5	21.5	21.5	21
Relative humidity min. (%)		50	52	67	85
Photo synthetically actual radiation mol m-2, day-1) e		35	19.5	4.9	0.5
Mean temperature (ºc) of soil	10 mm (max./ min)	35.5/25	35/23	30.5/23	25/22.5
	50 mm (max./ min)	29.5/25.3	31.5/24.5	25.5/24	24.5/25.5

Source: Whitmore TC. 1990. An Introduction to Tropical Rain Forest.P.102.

Change in temperature has been happened due to changes in albedo (Sagan.1979). Land use changes created differences in albedo which has important effects on the energy balance (Charney et.al 1975). Ground deprived of a vegetation cover as a result of deforestation has a very much higher albedo than ground covered in plants (Potter et. al 1975, Henderson et.al 1984). The lands covered by exotic species have higher albedo due to absence of ground covering vegetation. Research work of Pereira can reveal the relationship between temperature and vegetation cover (table 15).

Table 15: Albedo Value in Different Surface Type

Surface type	Location	Albedo (%)
Tall rain forest	kenya	9
Pine forest	Israel	12.3
Evergreen scrubs	Israel	15.9
Bamboo forest	Kenya	16
Oak forest	Israel	17.6
Deciduous wood land	England and Wales	18
Rough hill side grass	Israel	20.3
Conifer plantation	England	16
Agricultural grassland	England	24
Desert	Israel	37.3
Lake	Israel	11.3

Source: Pereira 1973

Table 15 shows that albedo value in different land coverings varies many times. Tall rain forest may have an albedo as low as 9% while the albedo value of hill ridge grasses is 20.3, in agricultural grasses 24, deciduous woodlands 18 and in deserts 37.3.

. The barren lands with shrubs or grasses have greater albedo. Natural bushes (bamboo can, small scattered trees with climbers and sufficient undergrowth) have also low albedo but greater than forestlands. Teak and acacia are totally devoid of under growth and they absorb soil moisture too much and no hilly springs originate from the ridges, covered by the monocultures. So, they must have very high albedo. Among them acacia is less exotic apparently. Teen and medium aged acacia gardens support very thin and small undergrowth (Shaheed 2007).

Vegetation cover controls day-night variation of temperature. In forestlands, diurnal temperature cannot rise too much due to co_2 uptake by dense vegetation and supply of 0_2 to atmosphere (AFC 1990).

Forestlands impeded solar energy in daytime and in night the rate of radiation is very low. For this, the diurnal temperature in forestlands is lower than outsides and nocturnal temperature is higher. Rationally, the day-night variation of temperature is not so high like barren lands (Barry and Chorely 1997).

Precipitation

Islam, Huda and Ali (1999) showed that average rainfall of hill area (Chittagong region) has been decreased slightly. Actually, in monsoon region deforestation causes reduction of rainy day not annual rainfall (Asthana2001). An interesting example of deforestation affecting rains is provided by rainfall data from Chotonagpur plateau of Bihar India which had a considerable area under forest cover in the beginning of 20th century. There were plenty of after noon shower during the summer months. Though there is not apparent reduction in monsoon rains over the plateau the afternoon showers have declined the number of rainy days excluding those of monsoon months, as. June, July and August were 374 during the four years period between 1870 and 1874 A.D. The number had gone down to 29 days during 1978 1982. The decline in the convection rains had caused the tea gardens of Chhotonagpur plateau to disappear (Meher, Homji, 1991).

Limitation: Present study recommends the following investigations for future researchers:

1. Measure CO_2 content in forest clad and deforested lands;
2. Measure albedo in different vegetation covers.

Problem of satellite image study: Satellite images show vegetation cover of study area had been increased in last decade (Chakma et.al. 2023, shown in Appendix 3). But actually, those are orchard or monoculture of pulpwood or commercial garden (Field Observation). They are not forest at all due to devoid of undergrowth and climbers (Shaheed 2007A, Mahmud and Chakma 2022). Due to this reality, RGA method has been adopted in this research. Actually, Satellite image study is not so essential in this research. The research is trying to reveal the micro-climate of natural forest, deforested barren land, grass land or shrubs and commercial gardens.

References

Aaron D, Matthew AP. 2014. Heart rate change and attitudes to global warming: A conceptual replication of the visceral fit mechanism. Journal of Environmental Psychology. 38:10–16.

Adnan 1998. 'Environment Development and the Indigenous People of Chittagong Hill Tracts; paper presented at a seminar on 'Development of CHTS', organized by FESD, Rangamati.

AFC (American Forest Council).1990. Trees. Journal of Forestry.90(9):12-14.

Afreen S, James L, Wescoat J, Salal H, Khurram A. 2012. An empirical analysis of the hydropower portfolio in Pakistan. Energy Policy. 50: 228–241.

Asthana DK, Asthana M. 2001. Environment; Problem and Solution. New Delhi: S Chand and Co.p.102-113,221-230,369-372.

Berkmuller K. 1992. Environmental; Education about the Rain Forest. UK: IUCN. 84p.

Barry RG, Chorely RG. 1968. Atmosphere, Weather and Climate. New York: U.S.A.

Brammer H. 1966. Reconnaissance Soil and Land use Survey Chittagong Hill Tracts 1964-1965. Canada: Forestal Forestry and Engineering International. 5p.

Bryant. 1997. The Last Frontier Forests-Ecosystem. U.S.A: World Resource Institute.p.87-93.

Chakma K. [Internet].2023. Climate Change Impacts on Chittagong Hill Tracts. UNDP: Asia Pacific Youth; [updated 2023 august 15; cited 2024 Jan 24]. Available from Available from yecap-ap.org

Chakma M, Hayat U, Meng J, Hassan MA.2023. An Assessment of Landscape and Land Use/Cover Change and Its Implications for Sustainable Landscape Management in the Chittagong Hill Tracts, Bangladesh. Land 2023, 12, 1610.Switzerland: MDPI [Internet]. [cited 2024 Jan. 26] ; Available from: https://doi.org/10.3390/land12081610

Day, Megaham.1975. Forest and Perennial Flow. U.k: Mc. Graw Hill. p. 54-67.

Dall'Olioet.al.1979.Recycling of Water in Amazon Basin: An isotopic study.Water Resource.**15**: 1250-1258.

Ellis CJ, Eaton S. 2021. "Microclimates hold the key to spatial forest planning under climate change: Cyanolichens in temperate rainforest". Global Change Biology. **27** (9): 1915–1926.

Feaderer CA. 1979. A Soil-Plant Atmosphere Model for Transpiration and Availability of Soil Water. Water Resources (U.S.A). 15:555-562.

Gain P. 1997. The Last Forest of Bangladesh. Dhaka: SEHD.p.1-49.

Gain P. 1998. Land Forest and Forest People. Dhaka: SEHD. p.29-50.

Gain P. 2000. The Chittagong Hill Tracts Life and Nature at Risk.Dhaka: SEHD.21p.

Gash JHC, Stewart JB. 1977. The Evaporation from Thetford Forest during 1975.Journal of Hydrology (England). 35:385-396.

Gates DM.1965. Transpiration and Leaf Temperature. Annals of Plant Physiology (London). 19:211-238.

Global forest Watch. [Internet].c2023. Chittagong Chittagong Banglagesh Deforestation Rates and Statistics; [cited 2024 January 22]. Available from: https:// www.globalforestwatch.org

Henderson, Sellers A, Gornitz V.1984. Possible Climatic Impacts of Land Cover Transformations with Particular Emphasis on Tropical Deforestation. Climatic Change.6:231-257.

Hutchinson RHS.1906. An Account of Chittagong Hill Tracts. Aalahabab:Pioneer Press.p.2-6.

Islam, Huda, Ali.1999. Chottogramer Brishtipater Poribortan. Bhugol Patrika (ISSN 1027-8567). Dhaka: Jahangirnagar University. p. 59-70.

Lewin TH. 1869. The Hill Tracts of Chittagong and the Dwellers Therein. Calcutta.

Lewin TH. 1912. Fly on the Wheel. London.

Marchak PM.1997. Logging the Globe. Canada: McGill Queen's University Press.10p.

Mahmud I, Chakma SB. [internet]c 2022.Orchards replace forests in Chittagong Hill Tract; In. Prothomalo.com [published 2022 March22; cited 2024 January22] Available from http://www.globalforestwatch.org

Meher-Homji VM. 1991.Climatic Change: The forest link. Madras: The Hindus Survey of India.p.55-77.

Periera HC.1973. Land use and Water Resources in Temperate and Tropical Climates. U.K: Cambridge University Press. p.68-76.

Pierre C, Yves A, Luc N, Bashir A. 2011. Modeling snowmelt-runoff under climate scenarios in the Hunza River basin, Karakoram Range, Northern Pakistan. Journal of Hydrology. 409: 1–2, 104–117.

Potter G.1975. Possible Climatic Impact of Tropical Deforestation. Nature(London). 258:697-698.

Puri GS. 1994.Forest Ecology. New Delhi: Oxford and IBH, pp.43-52,64-89,118-131.

Sagan.1979. Anthropogenic Albedo Change and Earth's Climate. Science. 206:1363-1368.

Salati E, Vose PB.1984. Amazon Basin: A system of equilibrium. Science.225**:**129-138.

Schendel VW. 2000. The Chittagong Hill Tracts: Living in a Border Land. Bankok: White Lotus.p.143-147.

Schweikert A., Paul C., Kyle K. and Xavier E.2014. The infrastructure planning support system: Analyzing the impact of climate change on road infrastructure and development. Transport Policy. 35:146–153.

Shaheed HZMH and Saleheen M.2001. Parbotto Chattogramer Jhum Chash Abong Poribeshgoto Patikria(in Bangla). Bhugol o Parivesa Jarnala. Dhaka:Bangladesh Geographical Society.1:127-146.

Shaheed HZMH. 2007B..Repeated and Excessive Slash and Burn Agriculture and Adverse Effects on Environment: A Case on Matamuhuri Catchment of South-Eastern Hill Regions of Bangladesh.LOK PROSHASHON SAMOEEKY. Dhaka: Bangladesh Public Administration Training Center.44:45-56.

Sojib, Hasan.2023. Evaluation of Environmental Changes of Sal Forest land cover using GIS and Remote Sensing Techniques: An Empirical Study on Arankhola, Madhupur Sal Forest in Bangladesh. Journal of Materials and Environmental Sciences.14(10):1197-1212.

Song F, Qi H, Wei H, Chang HH, Ruopu L, Zhenghong T. 2014. Projected climate regime shift under future global warming from multi-model, multi-scenario CMIP5 simulations, Global and Planetary Change. 112: 41–52.

SRDI 1997. Bhumi o Mrittika Shampad Babohar Nirdeshika(in Bengali). Dhaka: Ministry of Agriculture. 4p

Strasser U, Vilsmaier F, Prettenhaler T, Marke R, Steiger A, Damm F, Hanzer R, Wilcke J, Stötter J. 2014, Coupled component modelling for inter- and transdisciplinary climate change impact research: Dimensions of integration and examples of interface design, Environmental Modeling and Software, 60, 180–187.

Thornthwaite. 1933. The climates of the Earth. Geographical Review.23(1933):433-440

Trewartha.1968. An Inroduction to Climate. England: Mc.Grawhill.131p.

Waring RH. and Schlesinger.1985. Forest Eco-systems. London: Academic press. p.23-45.

Westall J, Stumm W. 1980. The Hydrosphere. In The Handbook of Environmental Chemistry (ed. Hutzinger O).Berlin: Springer. 1(A):17-49.

Whitemore TC.1990. Tropical Rain Forests. Oxford: Clarendon Press.p.102.

Yuksel G. 2014. Sea surface temperature anomalies at the Mediterranean Coast of Turkey (Period: 1968–2010). Procedia – Social and Behavioral Sciences. 31: 476–486.

Unpublished Document:

Bangladesh Meteorological Department. 2023. Temperatue Record of Rangamati. Unpublished.

Bangladesh Meteorological Department. 2023. Temperatue Record of Chittagong. Unpublished.

Bangladesh Meteorological Department. 2022. Temperatue Record of Rangamati. Unpublished.

Bangladesh Meteorological Department. 2018. Temperatue Record of Rangamati. Unpublished.

SCWM (Soil Conservation and Watershed Management). Temperature and Rainfall Report of Bandarban.Undated.

Shaheed HZMH. 2007A. Effects of Deforestatio and Depletion of Forest in South-Eastern Hill Region of Bangladesh. Ph,D Thesis. Bangladesh: Jahangirnagar University (Unpublished)

Appendix -1

Table-Highest temperature and variation of temperature in hilltops in BaliparavThanchi (May-2016)

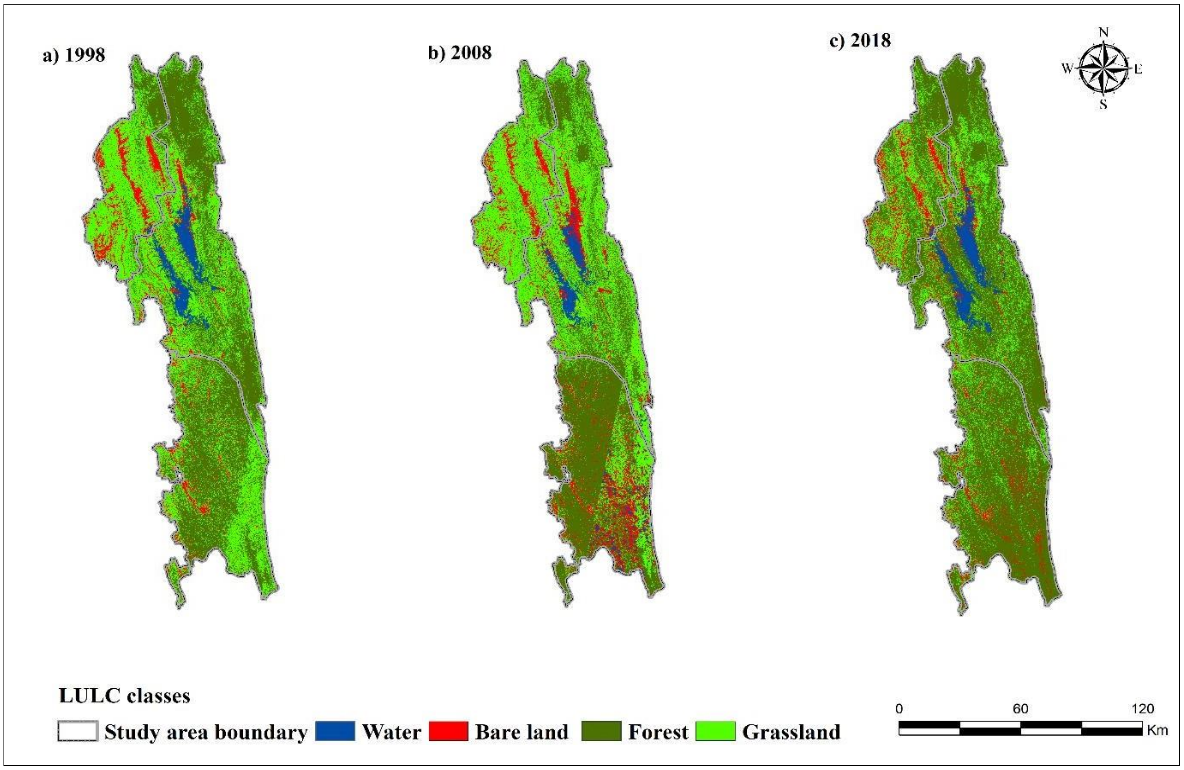
Station	Natural climax forest ^0C		Depleted land (very thin shrub or grass ^0C		Bushy area ^0C		Teak Monoculture ^0C		Orchard ^0C	
	HT	VT	HT	VT	HT	VT	HT	VT	HT	VT
1	30.0	07.5	43.0	17.0	34.0	08.9	44.6	20.0	42.5	18.5
2	29.6	07.5	42.8	17.0	35.4	09.3	44.2	21.8	43.9	19.8
3	29.8	07.4	43.2	17.4	34.4	08.5	44.8	21.8	43.0	19.5
4	30.6	07.6	42.9	17.9	33.7	08.6	43.0	21.8	42.8	18.5
5	31.0	07.4	43.2	18.9	34.8	08.7	43.6	20.1	41.8	19.9
6	31.3	07.5	44.0	19.0	35.0	08.6	46.0	22.0	42.7	19.7
7	30.8	07.5	44.2	19.6	34.5	08.0	45.5	20.5	41.9	19.8
8	28.6	06.8	38.7	17.8	32.6	08.5	40.0	20.2	39.6	19.4
9	29.7	06.7	37.8	17.0	31.8	08.4	41.4	20.5	39.9	19.7
10	28.9	06.8	39.6	17.4	32.0	07.8	41.2	20.0	38.9	19.7
11	30.8	07.5	38.0	17.2	32.8	07.9	42.6	20.6	38.7	19.2
Mean	30.1	7.33	41.5	18.2	32.4	8.4	44.2	21.6	41.4	19.5

Appendix -2

Table: Highest temperature and variation of temperature in hilltops in Bandarban (May-2018)

Station	Natural climax forest ^{0}C		Depleted land (very thin shrub or grass ^{0}C		Bushy area ^{0}C		Teak Monoculture ^{0}C		Orchard ^{0}C	
	HT	VT	HT	VT	HT	VT	HT	VT	HT	VT
1	29.0	07.2	43.0	17.0	36.0	9.7	43.0	21.0	41.6	18.6
2	29.0	07.2	42.0	17.2	34.2	09.0	44.5	20.5	42.8	18.5
3	29.8	07.4	43.4	17.5	33.8	09.5	44.0	20.6	40.9	18.4
4	30.0	07.5	42.9	18.0	35.4	9.5	43.5	20.2	42.7	18.5
5	30.6	07.0	43.7	18.5	35.6	9.0	43.6	19.8	41.7	18.4
6	30.3	07.5	44.0	18.7	36.6	9.5	45.0	21.5	42.4	18.2
7	30.8	07.3	44.7	19.5	36.5	9.5	45.5	21.0	41.0	18.0
8	29.6	06.8	38.7	17.2	31.8	9.4	42.0	20.2	40.8	18.0
9	28.7	06.8	37.3	17.5	32.0	9.2	42.4	20.1	42.5	18.4
10	28.9	7.6	39.0	17.0	33.9	9.8	41.2	20.0	40.9	18.2
11	30.8	07.6	40.0	18.0	34.8	9.7	43.6	20.6	41.5	18.4
Mean	30.4	7.2	41.6	17.8	34.6	9.5	43.7	20.6	41.7	18.4

Appendix – 3: Vegetation Cover Change in Chittagong Hill Tracts (From Satellite Images)



Source: Chakma et.al.2023

Appendix-4: Questionnaire and Formats for Data Collection (PRA SESSION)

Name of Participants & Status (Extra Sheet can be used)

Name of locality

1. What do you know about the Deforestation? Please mention the types of Deforestation in this locality.

2. How much forest have been Disappeared (through illegal or legal logging in your constituency?)

3. Please mention the climatological effect owing to deforestation.

   a. Rise in Temperature

   b. Decrease in Rain Fall

4. Is there any virgin natural forest in your locality?

5. Please mention the proportion of virgin natural forest (if exist)

6. Please mention the approximate proportion of land covering in your locality

   a. Barren land
   b. Grass land
   c. Bushes & Shrubs
   d. Natural compact forest
   f. Pulpwood Garden/Monoculture/Orchard

(Signature of Interviewer)

Appendix-5: Questionnaire for Key Informants (especially old people)

I. Name :
II. Age :
III. Locality :
IV. Occupation :
1. Please mention the proportion of forest cover in your locality in your early life & your forefather's

   a. First half of 20th century
   b. Before 20th century

2. Please mention the climatological condition of this locality in you early life or before

   a. Temperature

   b. Rain fall

3. Mention the change of forest cover in middle period of 1960-1980s.

   - Decrease significantly
   - Decrease of a few portion

[please draw the types of land cover on this circle showing proportion.]

4. Mention the climatological change in your medieval period of life (1960-1980)

   a. Temperature

   b. Rainfall

   b-1. Total rainy day of year

   b-2. Forest rainfall

(Signature of Interviewer)

[*Manuscript received on 9 November,2023; accepted on 15 December,2024*]