MICROCLIMATE CHANGE IN THE DARJEELING HIMALAYAS

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Introduction

There has been tremendous global concern over climatic changes and its impending effect over the ecosystems and biodiversity changes and ultimate influence over human settlements (Katwal, 2002). Vegetation is an index of climate. Any change in the existing vegetation, especially in mountainous regions, indicates deterioration in the ecosystem.

The Indian Himalayas comprise an area of 2,36,000 km^2. Darjeeling hills comprise an area of 3,149 km^2 of which 2,196 km^2 is forest cover (FSI, 2001). The National Forest Policy 1988 emphasizes on protective function of forest in maintaining ecological balance and environmental stability and aims to have a minimum of one-third of the geographical area of the country under forest or tree cover. The policy aims at maintaining two-thirds of the area in hills under forest cover. The Darjeeling hills have improved 46.2 per cent forest cover to 69.74% of its total geographical area since 1997-2001 (FSI, 1997, 2001). Like other parts of our country, forests and landscape changes in Darjeeling hills are victims of development for centuries. The population of Darjeeling District has increased by 1596% since 1872 to 2001. During 1872-81 annual growth of population of Darjeeling District was 7%, which was mainly due to migration of people from neighbouring states and Nepal to participate in several developmental activities e.g., tea gardens, creations and establishment of narrow gauge railway. Impact of population growth resulted in several landscape changes and deforestation in the Darjeeling hills (Starkel and Basu, 2000) consequences of which were experienced in rainfall pattern changes (Ram and Patel, 1995). Daily rainfall data at places in foothills, subtropical zone and temperate zone (all parameters) of Balason catchment of Darjeeling hills has been analyzed and the results have been described.

Study Sites

The study sites – Mohargaon, Semulebari, Lohagarh, Sepoydhora and Gayabari are located within longitudes 88°11'12" and 88°25' E and latitudes 26°48" and 26°51" N in the foothills; Phuguri and Thurbo within longitudes 88°10'18" and 88°18'36" E and latitudes 26°48'18" and 26°53'24" N in western edge of Balason catchment and Sonada at longitude 88°16'4" E and latitude 26°59'8" N in Senchal Wildlife Sanctuary within Balason catchment of Darjeeling hills. The areas

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categories season-wise as winter (Jan.-Mar. and Oct.-Dec.), pre-monsoon (April-May) and monsoon (June-Sept.). In the foothills (Mohargoan) average rainfall was 3003.3 mm, 82 per cent of which is contributed by monsoon, 9 per cent each by pre-monsoon and winter. In the Senchal Wildlife Sanctuary (E.W. Sonada), average annual rainfall was 3620.1 mm of which 79.7 per cent is contributed by monsoon, 12.8 per cent by pre-monsoon and 7.5 per cent by winter.

Foothills area experiences maximum and minimum temperature of 36°C and 2°C respectively whereas the same was 30°C and below 0°C in the sub-tropical and wet temperate zones. Seven Tea estates viz Mohargaon, Semulebari, Lohagarh, Sepoydhora, Gayabari, Phuguri and Thurbo record daily rainfall data vis-a-vis daily meteorological data recorded at Sonada and Sukna by Environmental Research Station (I.F.P., L.C.F.R.E.) Sukna, Darjeeling, have been utilized for this study. Mohargaon, Sukna, Sepoydhora and Sonada observatories are located on the Siliguri-Darjeeling road at elevation of 152m, 170m, 609.6m and 2,150m respectively; Gayabari, Phuguri and Thurbo on the Siliguri-Mirik-Ghoom Darjeeling road on 800m, 1,257m and 1,680m elevation respectively. Lohagarh observatory is located on 243.8m elevation of Mechi river bordering Nepal. Forest types in the area are tropical moist deciduous ($3C/C_3b$), Sub-Himalayan wet mixed ($2B/C_1/2S_3$) and wet temperate forest ($11B/C_1$) (Champion and Seth, 1968).

Major natural species are *Shorea robusta, Dalbergia sisoo*, *Bombax ceiba, Michelia champaca, Terminalia* sp., *Ailanthus grandis*, *Betula* sp., *Acer* sp., *Castonopsis* sp., *Alnus nepalensis*, *Schima wallichi*, bamboos and plantation of *Tectona grandis* in foothills, *Cryptomeria japonica*, *Pinus patuala, Semingtonis poplnea, Castanopsis* sp. *Acer* sp., *Machilus, Betula alnoids* and other broad leaves species in sub-tropical and wet temperate hills.

Material and Methods

Tea estates located in the Eastern Himalayan regions maintain record of daily rainfall in inches/cm/mm with their desired diameter of rain gauge and with deviating times of measurements. Environmental Research Station, Sukna and Sonada maintain their daily meteorological data as per all India Meteorological standards and as per time fixed by them. For analysis of data only number of rainy days of all tea estate observatories were taken because they have no standard rain-gauge and even standard time of measurement of rainfall. Average monthly number of rainy days data is present in Table 1.

Coefficient of variations (C.V.) of number of rainy days of all observatories (Table 1) has been analyzed. Climatological attributes of Experimental Watershed, Sonada, located within Senchal Wildlife Sanctuary are presented in Table 2. Seasonal five years total numbers of rainy days of all observatories were added. Seasonal total number of rainy days of the same have been grouped as winter, pre-monsoon, monsoon and subsequently added together to get annual five years total number of rainy days. Percentage of increase/decrease in seasonal, and annual number of rainy days were compared with the average as standard and have been presented in Table 3-9 for 7 Tea Estates separately. The net result in increase or

Table 1

Monthly average number of rainy days in Darjeeling Himalaya

Month	Tea Estates Observatories							Experimental Watershed Sonada (13yrs)
	Mohar-gaon (47 yrs)	Semule-bari (53yrs)	Loha-garh (80yrs)	Sepoy-dhora (34yrs)	Gaya-bari (64yrs)	Phuguri (48 yrs)	Thurbo (53yrs)	
January	2	2	2	1	2	2	3	8
February	2	2	3	2	3	3	3	11
March	4	4	3	3	4	4	4	10
April	8	8	8	8	8	8	9	15
May	16	16	15	14	16	16	15	26
June	22	23	22	22	23	23	22	28
July	25	26	24	24	26	27	25	30
August	21	24	22	19	24	25	22	29
September	18	20	18	17	20	20	17	25
October	7	9	8	7	8	7	6	14
November	2	2	2	2	2	2	2	4
December	1	1	1	1	1	1	I	3
Total	128	137	128	120	137	138	129	203
C.V.	8.45	9.89	10.99	15.32	12.03	15.32	20.29	9.19

decrease in percentage for a period of 5 years block is presented in Table 10. Population growth of Darjeeling District is presented in Fig. 1. Annual maximum temperature (°C) with average temperature of Experimental Watershed, Sonada is presented in Fig. 2. Comparative annual rainfall and number of rainy days of Experimental Watershed, Sonada with ERS, Sukna observatory is presented in Figs. 3 and 4 respectively.

Results and Discussion

Comparative monthly average number of rainy days of Mohargoan (47 yrs), Semulebari (53 yrs), Lohagarh (80 yrs), Sepoydhora (34 yrs), Gayabari (64 yrs), Phuguri (48 yrs), Thurbo (53 yrs) and Sonada (13 yrs) are presented in Table 1 with their total number of rainy days of 128, 137, 128, 120, 137, 138, 129 and 203m respectively. Table 1 reveals that at Mohargaon, Semulebari, Lohagarh, Sepoydhora, Gayabari, Phuguri and Thurbo observatories annual number of rainy days are less by 36.94%, 32.52 %, 36.94 %, 40.89 %, 32.52 %, 32 % and 34.45% respectively than number of rainy days at E.W. Sonada observatory.

Table 1 also reveals that at Mohargaon observatory, coefficient of variation of number of rainy days is less

Table 2

Average monthly climatological data of Experimental Watershed, Sonada, Darjeeling (1990-2002)

Month	Rainfall (mm)	No. of Rainy days	Temp. (°C)			Relative Humidity (%)		Vapour Pressure (MB)		Sunshine brightness (hrs/day)	Wind Velocity (km/hr)
			Max.	Min.	Mean	06.37	13.37	06.37	13.37		
January	26.7	8	17.4	1.6	9.4	86	90	6.93	13.19	4.4	1.73
February	35.0	11	17.7	2.7	10.2	88	92	7.62	13.21	3.9	1.51
March	60.8	10	20.2	5.9	13.0	89	91	9.38	15.38	4.3	1.82
April	175.7	15	22.5	8.8	15.7	87	90	11.75	18.43	4.4	2.10
May	287.7	26	22.7	11.1	16.9	93	93	14.61	19.70	3.0	1.66
June	699.2	28	22.3	13.6	17.9	94	94	16.57	20.84	1.3	1.66
July	932.8	30	22.1	14.3	18.1	95	95	17.37	21.04	1.0	1.75
August	763.1	29	22.6	14.1	18.3	95	95	17.18	21.40	1.4	1.61
September	490.4	25	23.0	12.8	17.9	94	94	15.83	20.89	2.1	1.71
October	100.3	14	23.7	9.7	16.7	90	89	12.79	19.74	4.8	1.62
November	36.5	4	22.8	6.4	14.6	87	87	9.94	18.36	5.5	1.97
December	12.0	3	19.8	3.1	11.5	84	89	7.70	18.58	5.2	1.91
Total	3620.1	203	-	-	-	-	-	-	-	41.3	-
Average	-	-	21.4	8.7	15.0	90	92	12.30	18.12	3.4	1.75

Table 3

Seasonal five years total number of rainy days at Mohargaon Tea Estate of Darjeeling Himalaya foothills

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1958-62	80	-6.00	110	-10.00	451	+4.00	641	+0.39
1963-67	78	-9.00	133	+9.00	481	+ 11.00	692	+8.29
1968- 72	75	-12.00	124	+2.00	446	+3.00	645	+0.94
1973-77	78	-9.00	140	+15.00	427	-1.00	645	+0.94
1978-82	78	-9.00	107	-12.00	390	-10.00	575	-10.02
1983-87	82	-4.00	110	-10.00	424	-2.00	616	-3.60
1988-92	89	+4.00	114	-6.00	397	-8.00	600	-6.10
1993-97	104	+22.00	118	-3.00	419	-3.00	642	+0.47
1998-2002	99	+60.00	140	+15.00	459	+6.00	698	+9.23
Average	85	-	121	-	433	-	639	-

Increase or decrease % in comparison with average

than rest of all observatories. Turbo observatory shows greater variability in number of rainy days followed by Sepoydhora and Phuguri observatories. Seasonal distribution of rainy days at all tea estates observatories show almost similar trend in all seasons except Sonada observatory. Table 3 shows monthly climatologically attributes of Sonada observatory located in the wet temperate zone of Darjeeling Hill. The area experiences regular rainfall. Increase in minimum temperature from January to July and decrease of the same from August to December can be observed from the Table 3. Table described the climatological condition as annual relative humidity 90 - 92% at 06.37 and13.37 hrs; vapour pressure (mb) 12.30 and 18.12 at 06.37 hrs and 13.37 hrs;sunshine brightness (hrs/day) 3.4 and 1.75, respectively.

Increase in annual maximum temperature is shown in Fig. 2. Figs. 3 and 4 describe change in rainfall amount and number of rainy days at ERS, Sukna with almost slight change due to impact of conservation of Mahananda Wildlife Sanctuary. Meteorological observatory at Sonada is located on the fringe of natural and plantation forests. The forest edge, it is well known, shows special conditions which can be called “fringe micro-climate” and which may have this influence for the crop lands adjoining the forest (Anon., 1962). The microclimate changes to Sonada observatory may be due to the nearby natural forest and plantations. Fig. 1 shows

Table 4

Seasonal five years total number of rainy days at Simulebari Tea Estate, Darjeeling Himalaya foothills

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1953-57	101	+2.02	105	-11.76	489	+4.93	695	+1.61
1958-62	100	+ 1.01	112	-5.88	484	+3.86	696	+1.75
1963-67	99	0	123	+3.36	508	+9.01	730	+6.72
1968- 72	107	+8.08	130	+9.24	502	+7.72	739	+8.04
1973- 77	109	+10.10	137	+15.13	492	+5.58	738	+7.89
1978-82	120	+21.21	127	+6.72	446	-4.29	693	+1.31
1983-87	95	-4.04	111	-6.72	446	-4.29	652	-4.68
1988-92	90	-9.09	108	-9.24	422	-9.44	620	-9.36
1993-97	106	+7.07	115	-3.36	455	-2.36	676	-1.17
1998-2002	62	-37.37	119	0	417	-10.51	598	-12.57
Average	99	-	119	-	466	-	684	-

Increase or decrease % in comparison with average

population growth and annual growth rate of Darjeeling District since 1872 to 2001 and the Table also shows total growth increase by 1596 per cent since 1872-2001. Annual growth rate within 1872- 1881 was 7%, which was due to migration of people from Nepal involved in creation of several tea estates and establishment of narrow meter gauge railway and several other economic activities (Starkel and Basu, 2000). Annual population growth rate of the district decreases till 1901-11 and again increased since 1921-31 to 1951-61. Annual population growth rate of the district during 1991-2001 is much more than all India annual population growth rate due to political reasons in neighbouring countries, more employment and even political stability in the state. In 1901 about 51.54% of the total area of the Darjeeling District was covered by forest, in 1921 it was 49.14%, in 1931 - 45.46%, in 1941 - 45.08%, in 1951 - 45.01%, in 1961 - 40.07%, in 1971 - 38.03%, in 1981 - 38 20% (Starkel and Basu, 2000) and landscape changes in the district at alarming stage and subsequently resulting change in climate. In Darjeeling hills, increase in dense forest cover in 2001 with respect to 1999 was 29.29% whereas increase in open forest cover was 117%. Open forest cover during 1999 was 32.7% in comparison to dense forest cover whereas it was 55.9% during 2001 (FSI, 2001). The impact of population

Table 5

Seasonal five years total number of rainy days at Lohagarh Tea Estate, Darjeeling Himalaya foothills

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1923-27	82	-6.82	135	+17.39	458	+5.53	675	+5.96
1928-32	116	+31.82	116	+0.87	443	+2.07	675	+5.96
1933-37	78	-11.36	94	-18.26	406	-6.45	578	-9.26
1938-42	64	-27.27	97	-15.65	406	-6.45	567	-10.99
1943-47	64	-27.27	124	+7.83	396	-8.75	584	-8.32
1948-52	91	+3.41	128	+11.30	427	-1.61	646	+1.41
1953-57	101	+14.77	109	-5.22	459	+5.76	669	+5.02
1958-62	96	+9.09	98	-14.78	457	+5.30	651	+2.20
1963-67	84	-4.54	105	-8.69	452	+4.15	641	+0.63
1968- 72	82	-6.82	117	+1.74	472	-8.76	671	+5.34
1973- 77	107	+21.59	122	+6.08	457	+5.30	686	+7.69
1978-82	98	+11.36	118	+2.61	456	+5.07	672	+5.49
1983-87	84	-4.54	118	+2.61	450	+3.69	652	+2.35
1988-92	96	+9.09	113	-1.74	402	-7.37	611	-4.08
1993-97	87	-1.14	130	+13.04	374	-13.82	591	-7.22
1998-2002	85	-3.40	123	+6.95	421	-2.99	629	-1.25
Average	88	-	115	-	434	-	637	-

Increase or decrease % in comparison with average

growth on microclimate change is also adding due to increased in carbon dioxide by the combustion of fossil fuel, emission from vehicles in the atmosphere and several developmental activities. Several authorities have reported the impact of large-scale deforestation and landscape changes on climate change (Anon., 1962, 1988, 1995). At Mohorgaon observatory (Table 3) improvement of number of rainy days has been observed annually for the last two decades whereas during winter it was for last two and half decades and during pre-monsoon and monsoon for 5 years. The observatory is located on edge of Mahananda Wildlife Sanctuary and the increase may be due to impact of forest and its conservation (Ram and Patel, 1995). Table 4 reveals seasonal number of rainy days changes with average number of rainy days with five years blocks of Semulebari tea estate observatory. Winter season

Table 6

Seasonal five years total number of rainy days at Sepoydhora Tea Estate, Darjeeling Himalaya foothills

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1973- 77	95	+11.76	127	+19.81	428	+7.00	650	+9.98
1978-82	93	+9.41	105	-0.94	422	+5.50	620	+4.91
1983-87	88	+3.53	97	-8.49	424	+6.00	609	+3.04
1988-92	64	-27.27	92	-13.21	327	-18.25	483	-18.47
1993-97	81	-7.95	97	-8.49	387	-3.25	565	-4.40
1998-2002*	91	+3.41	119	+ 12.26	411	+2.75	621	+5.07
Average	85	-	106	-	400	-	591	-

Increase or decrease % in comparison with average
*Due to closure of observatory since 2000-02, data was collected from nearby observatory

experiences decrease in number of rainy days for 1998-2002 blocks whereas pre-monsoon season have shown decrease in number of rainy days for two decades. Monsoon season experienced decrease in number of rainy days for two and half decades and annual for the last two decades. Sharp decrease in number of rainy days was observed during 1998-2002. The decrease in number of rainy days may be due to deteriorative biological activities going on in nearby forest areas as observed. At Lohagarh observatory (Table 5) irregular pattern in number of rainy days can be observed in all reasons. Decrease in number of rainy days can be also observed during monsoon seasons for last one and half decades. Annual number of rainy days decrease has been observed here for the last two decades. This may be due to deforestation impact in India and bordering Nepal. Decrease in number of rainy days at Sepoydhora observatory in all block years is given in Table 6. This observatory also falls under Mahananda Wildlife Sanctuary and conservation impact can be observed in improvement of number of rainy days for last five years. Table 7 reveals number of rainy days decreases at Gayabari observatory in winter and monsoon seasons and annual for last two and half decades this may also be due to socio-economic impact on nearby forest and reduction in vegetation cover. Table 8 reveals irregular pattern in number of rainy days at Phuguri observatory during all seasons. But slight decrease in number of rainy days annually has been observed for last one decade. The area is surrounded by forest on lower side but is being degraded for the past two decades as per query made with local people and personal visit revealed the

Table 7

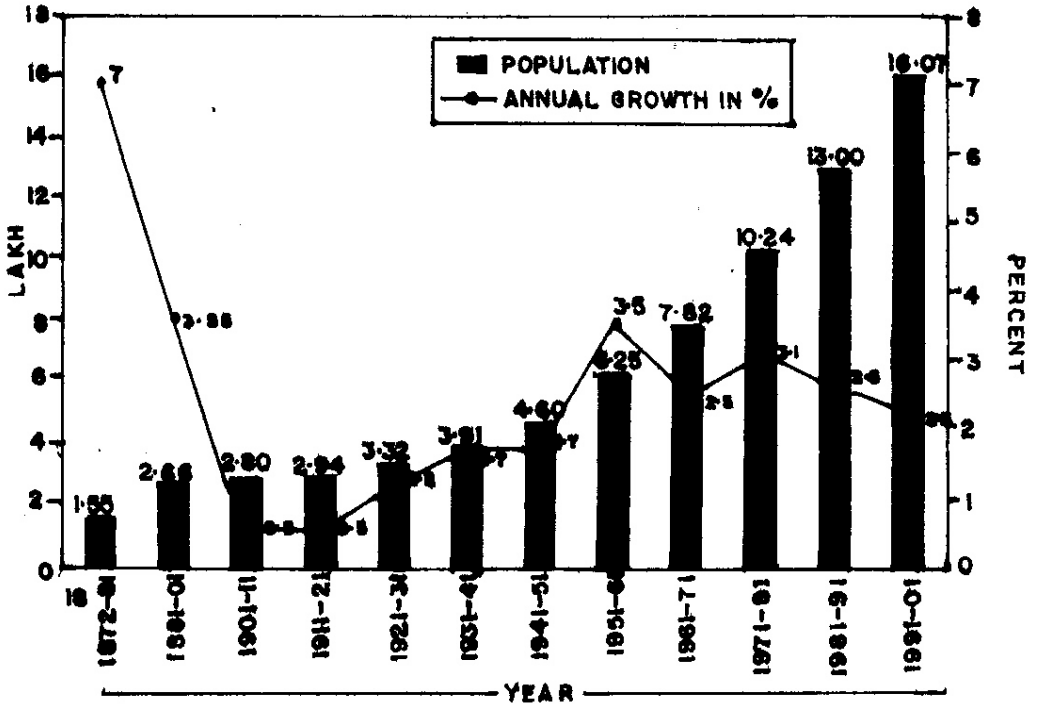
Seasonal five years total number of rainy days at Gayabari Tea Estate, Darjeeling Himalaya foothills

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1943-47	157	+48.11	140	+ 12.90	501	+8.68	798	+15.48
1948-52	125	+17.92	160	+29.03	527	+14.32	812	+17.51
1953-57	111	+4.72	103	-16.93	489	+6.07	703	+1.74
1958-62	108	+ 1.89	104	-16.13	478	+3.68	690	-0.14
1963-67	88	-16.98	124	0	498	+8.03	710	+2.75
1968- 72	91	-14.15	127	+2.42	495	+7.37	713	+3.18
1973- 77	107	+0.94	139	+12.10	460	-0.22	706	+2.17
1978-82	103	-2.88	126	+1.61	440	-4.55	669	-3.18
1983-87	91	-14.15	122	-1.61	426	-7.59	639	-7.52
1988-92	104	-1.89	112	-9.67	406	-11.93	622	-9.98
1993-97	84	-20.75	98	-20.98	364	-21.04	546	-20.98
1998-2002*	100	-5.66	137	+1048	444	-3.69	681	-1.45
Average	106	-	124	-	461	-	691	-

Increase or decrease % in comparison with average
*Data for the year 2000-2001 was collected from nearby observatory due to close of observatory

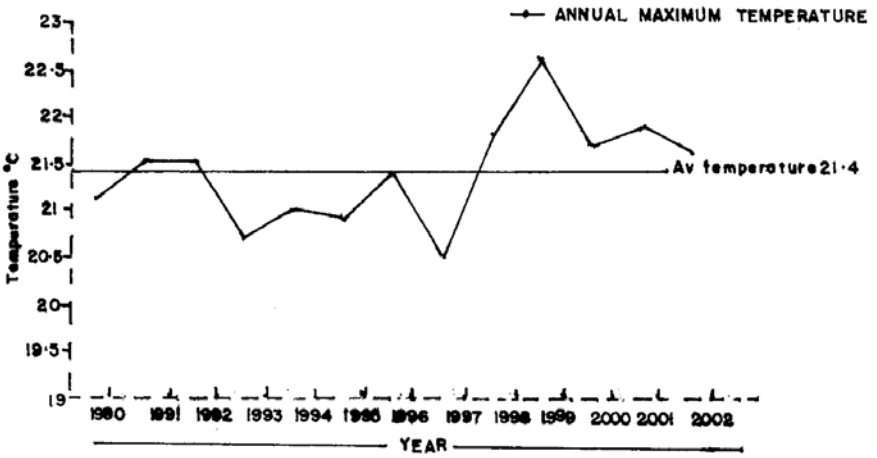
consequences of the same might be irregular change in number of rainy days at the observatory. At Thurbo observatory sharp decrease in number of rainy days in all seasons including annual can be observed in Table 9. The observatory is located on Nepal border. Deforestation in Nepal and even in India by local people of both the countries mostly during 1985-87 during the Gorkha National Liberation Front (GNLF) agitation and the growth impact of nearby Mirik township of tourist importance may have the direct impact in reduction in number of rainy days for the last two decades. Table 10 summarizes the decrease or increase in number of rainy days at glance of all observatories located under different climatic zones of Darjeeling hills. Annual decrease in number of rainy days at Mohargaon and Sepoydhora observatories are less in comparison of Semulebari, Gayabari and Turbo observatories and this may be due to their location in nearby forest (Ram and Patel, 1995). Decrease in number of rainy days supports findings of Mehar-Homji (1988). Dhabriya (1988), Ram and Patel (1995), Rawat and Rawat (1998), Ram (1998, 2000).

Fig. 1



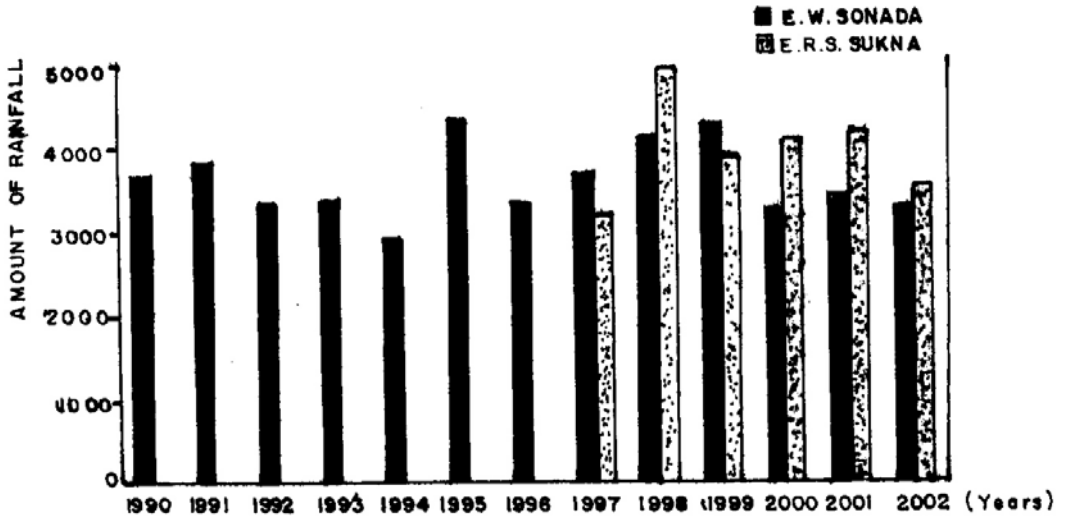
Population growth of Darjeeling District

Fig. 2



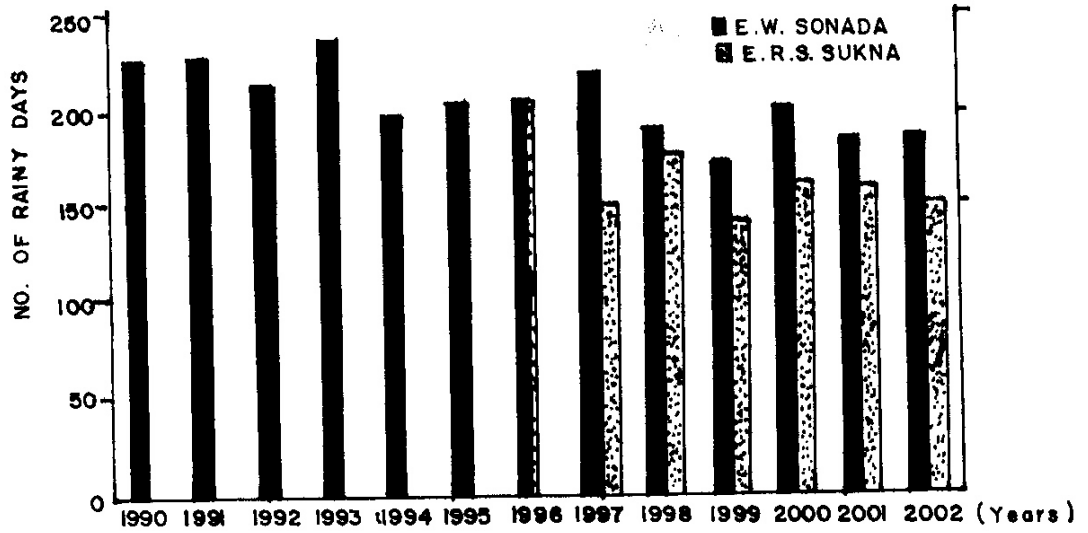
Annual maximum temperature of E.W. Sonada, Darjeeling

Fig. 3



Comparative annual rainfall of E.W. Sonada and E.R.S. Sukna, Darjeeling

Fig. 4



Comparative annual number of rainy days of E.W. Sonada and E.R.S. Sukna, Darjeeling

Mehar-Homji (1988) describes that change of vegetation on climate provide evidence of tendency for rainfall and rainy days to decrease with a drastic decrease in

Table 8

Seasonal five years total number of rainy days at Phuguri Tea Estate, Darjeeling Himalaya upper foothills

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1958-62	107	+5.94	113	-6.61	506	+6.53	726	+4.16
1963-67	87	-13.86	115	-4.96	503	+5.89	705	+1.15
1968- 72	82	-18.81	109	-9.92	504	+6.10	695	-0.29
1973- 77	102	+0.99	139	+14.88	469	-1.26	710	+1.86
1978-82	76	-24.75	119	-1.65	424	-10.74	619	-11.19
1983-87	69	-31.68	122	+0.83	446	-6.10	637	-8.61
1988-92	110	+8.91	123	+1.65	486	+2.31	719	+3.16
1993-97	100	-0.99	108	-10.74	479	+0.84	687	-1.43
1998-2002	78	-22.77	144	+19.01	455	-4.21	677	-2.87
Average	101	-	121	-	475	-	697	-

Increase or decrease % in comparison with average

forest cover. At first, deforestation may not have much effect on rainfall but in the long run it certainly does.

The consequences of decrease in forest cover since 1901 to 1981 on number of rainy days changes can be observed at all described observatories. The improvement of forest cover since 1997-2001 impact shows improvement in reduction of number of rainy days sharpness mostly nearby sanctuary. Recurring disturbances of forest cover nearby Gayabari and Semulebari observatories are being observed in alarming stages whose consequences are may be reduction in number of rainy days. Turbo observatory shows sharp decrease in number of rainy days than other observatory may be due to much more biological stresses on existing vegetation coverage and deforestation being an open International Border. All observatories except Mohargaon and Sepoydhora show decrease in number of rainy days mostly for one to two and half decades, which may be due to over-exploitation of green cover with increasing biological activities to meet the increasing population demands.

Conclusion and Recommendations

Mountain ecosystems are mother of several rivers, extremely fragile and susceptible to soil erosion and landslides with vulnerable habitat and genetic diversity leading to ecological imbalance. The United Nations has proclaimed the

Table 9

Seasonal five years total number of rainy days at Thurbo Tea Estate, sub- tropical hill in Darjeeling Himalaya

Block Years	Seasons						Total	Increase or Decrease (%)
	Winter (Jan. to Mar. & Oct. to Dec.)	Increase or Decrease (%)	Pre-monsoon (April to May)	Increase or Decrease (%)	Monsoon (June to Sept.)	Increase or Decrease (%)		
1953-57	127	+44.32	134	+15.52	508	+19.25	769	+22.06
1958-62	108	+22.73	117	+0.86	484	+13.61	709	+12.54
1963-67	97	+10.23	135	+16.38	479	+12.44	711	+12.86
1968- 72	88	0	132	+13.79	492	+15.49	712	+13.02
1973- 77	87	-1.34	138	+18.96	450	+5.63	675	+7.14
1978-82	120	+36.36	127	+9.48	434	+1.88	681	+8.09
1983-87	86	-2.27	100	-13.79	395	-7.28	581	-7.78
1988-92	63	-28.41	92	-20.69	309	-27.46	464	-26.35
1993-97	67	-23.86	89	-23.28	377	-11.50	533	-15.40
1998-2002	40	-54.54	95	-18.1 0	329	-22.77	464	-26.35
Average	88	-	116	-	426	-	630	-

Increase or decrease % in comparison with average

year 2002 as the International Year of the Mountains to create awareness amongst nature lovers, political, planner and on social levels to contribute their might in protecting this huge ecosystem, on sustainable development basis. The Darjeeling hills have a lot of degraded land especially on Tea Garden land to be restored with green cover with participatory involvement for improvement of degraded environment for regaining of regular number of rainy days. Proper planning and management of natural resources particularly soil and water conservation with proper motivation to local people for this sustainable development has to be initiated while planning the socio economic condition of the people of the area has to be given due consideration. Programme of family welfare needs to be top priority. It is important to realize that equidistributed rainfall over the monsoon can be realized by increasing the green cover to the fragile Himalayan eco - system. This will prove a boon to the welfare not only of the hill people but all round development and happiness of the people of plains also. Non-Government organization and scientific organization can play key roles in materializing the above goals through programmatic planning.

Table 10

Comparative five years number of rainy days pattern changes under different climatic zones of Darjeeling Himalaya

Block Years	Tea Estates Observatories							Experimental Watershed Sonada (2150m amsl)
	Mohar-gaon (152m amsl)	Semule-bari (200m amsl)	Loha-garh (243.8m amsl)	Sepoy-dhora (609.6m amsl)	Gaya-bari (800m amsl)	Phuguri (1257m amsl)	Thurbo (1680m amsl)	
1923-27			+5.96					
1928-32			+5.96					
1933-37			-9.26					
1938-42			-10.99					
1943-47			-8.32		+15.48			
1948-52			+1.41		+17.51			
1953-57		+0.61	+5.02		+1.74		+22.06	
1958-62	+0.31	+1.75	+2.20		-0.14	+4.16	+12.54	
1963-67	+8.29	+6.72	+0.63		+2.75	+1.15	+12.86	
1968- 72	+0.94	+8.04	+5.34		+3.18	-0.29	+13.02	
1973- 77	+0.94	+7.89	+7.69	+9.98	+2.17	+1.86	+7.14	
1978-82	-10.02	+1.31	+5.49	+4.91	-3.18	-11.19	+8.09	
1983-87	-3.60	-4.68	+2.35	+3.04	-7.52	-8.61	-7.78	
1988-92	-6.10	-9.36	-4.08	-18.47	-9.98	+3.16	-26.35	
1993-97	+0.47	-1.17	-7.22	-4.40	-20.98	-1.43	-15.40	+6.00
1998-2002	+9.23	-12.57	-1.25	+5.07	-1.45	-2.87	-26.35	-7.00

+ (Increase) – (Decrease) % in comparison with average.

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SUMMARY

The Indian Himalayas comprising an area of 2,36,000 km². Darjeeling Himalaya comprises an area of 3149 km² with 69.74% of forest cover. Darjeeling District population registered an increased of 1596% upto 2001 since1872. During 1872-1881 annual population growth rate was registered 7% due to several developmental activities i.e. road, rail, tea garden establishment, etc on forest lands. This paper describes the effect of forest conservation impact on improvement of rainy days nearby Wildlife Sanctuary and on reduction in number of rainy days having consequences of reduction in forest cover. Sharp decrease in number of rainy days has been

registered near by Nepal border and near by forest fringe observatories due to over exploitation of forest cover. Declining in rainfall and increased in maximum temperature was observed on observatory under wet temperate zone. Variability of number of rainy days in the observatory improves in its number was observed less than the observatories showing decrease in number of rainy days. The present study indicates that Darjeeling Himalayas mostly faced decrease in number of rainy days other than sanctuary areas. Regaining of deteriorating microclimate (number of rainy days) of the 'queen of hills' can be restored by improvement of tree covers to the deteriorated forests and creating awareness among local people on sustainable management basis.

दार्जिलिंग के हिमालयी भूभांग की अणुजलवायु में हुए परिवर्तन

निर्मल राम व एस०एन० मजुमदार

सारांष

भारत के सम्पूर्ण हिमालयी क्षेत्र 2,36,000 किमी^{2} में दार्जिलिंग का हिमालय भूभाग 3149 किमी^{2} है जिसका 69.74 % भाग वनाच्छादित है। दार्जिलिंग जिले की जनसंख्या में 1872 से 2001 तक 1596 % वृद्धि हुई है। 1872–1881 के दौरान अनेक विकास कार्यकलापों, जैसे सड़क, रेल, चाय बगीचों की वन भूमियों पर स्थापना की जाने के कारण वार्षिक जनसंख्या वृद्धि की दर 7% रहती देखी गई। इस अभिपत्र में वन्यप्राणि अभयारण्यों के पास वर्षा होने वाले दिनों में सुधार पर वन संरक्षण से पड़ते प्रभावों तथा वर्षा होने वाले दिनों की संख्या घटने से वन आवरण में कमी होने के परिणामों को वर्णित किया गया है। नेपाल सीमा तथा वन आवरण के अति–समुपयोजन के कारण वन झालर के पास बनी वेधशालाओं के निकट वर्षा होने वाले दिनों की संख्या में बहुत कमी हुई है। वर्षा में कमी और अधिकतम तापमान में वृद्धि आर्द्र समशीतोष्णा भूक्षेत्र की वेधशाला में प्रेक्षित की गई। वेधशाला में वर्षा–दिनों की संख्या में पड़ा अन्तर उससे कहीं ज्यादा है जितना कि वर्षा दिनों में आई कमी वेधशाला में दिखाई पड़ रही है। प्रस्तुत अध्ययन संकेत देता है कि दार्जिलिंग के हिमालयी भूभाग को, अभयारण्य वाले क्षेत्रों को छोड़कर सामान्यतः वर्षा दिनों में कमी को झेलना पड़ा है। पर्वतों की रानी में व्याहसित होती जा रही अणुजलवायु (वर्षा दिनों की संख्या) की पुनप्राप्ति को व्याहसित वनों के वृक्षावरण में सुधार लाकर और स्थानीय जनता को लम्बे समय तक उनका प्रबन्ध करते रहने के आधार पर जागरूक बनाकर ही वापस लाया जा सकता है।

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