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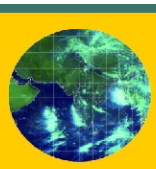

RR No.
1/2011

NCC RESEARCH REPORT

Impact of Climate Change on Land Degradation over India

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NATIONAL CLIMATE CENTRE
OFFICE OF THE
ADDITIONAL DIRECTOR GENERAL OF METEOROLOGY (RESEARCH)
INDIA METEOROLOGICAL DEPARTMENT
PUNE - 411 005

National Climate Centre
Research Report No. 1 / 2011

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INDIA

INDIA METEOROLOGICAL DEPARTMENT
DOCUMENT AND DATA CONTROL SHEET

1	Document title	Impact of Climate Change on Land Degradation over India
3	Issue No.	NCC Research Report No.1/2011
4	Issue date	May, 2011
5	Security Classification	Unclassified
6	Control Status	Uncontrolled
7	Document type	Scientific Publication
8	No. of Pages	12
9	No. Figures	1
10	No. of references	6
11	Distribution	Unrestricted
12	Language	English
13	Authors	P.G. Gore, B.A. Roy and H.R. Hatwar
14	Originating Division/Group	Investigation and Development Section, Office of ADGM(R), India Meteorological Department , Pune.
15	Reviewing and Approving Authority	Director General of Meteorology, India Meteorological Department, New Delhi.
16	End users	Central and State Ministries of Agriculture, Science and Technology, Disaster Management Agencies, Research Institutes and Agricultural Universities.
17	Abstract	The studies of UNEP (United Nations Environmental Programme) indicated that, over the preceding 20 years, the problem of land degradation had continued to worsen due to human activities and climate change such as prolonged or frequent droughts aggravating land degradation. This led formally defining desertification as “land degradation” in arid, semi-arid and dry sub-humid areas which is used as basis of the UNCCD (United Nations Convention to Combat Desertification). India became a signatory to UNCCD during 1994. One of the obligations of all developing country parties to the convention, including India, is to prepare the National Action Programme to Combat Desertification and to mitigate the effects of drought. In the present study, land degradation over the country has been examined with the help of soil moisture status which has been quantified by a moisture index (P/PE) where P is rainfall and PE is Potential Evapotranspiration.
18	Key words	Arid, Semi Arid, Dry Sub-Humid, Potential Evapotranspiration, Land degradation, Moisture Index, UNCCD.

1. Introduction

Desertification has long been recognized as a major environmental problem affecting the livelihood of the people in the affected regions in many countries of the world. In 1977, a United Nations Conference on Desertification (UNCOD) was convened in Nairobi, Kenya to produce an effective, comprehensive and co-ordinated programme for addressing the problem of land degradation. The UN Commission for Sustainable Development Report 1988 observed that desertification has become one of the most serious environmental and socio-economic problems of the world. The various assessments by UNEP continued to point out that desertification results from complex interactions among physical, chemical, biological, socio-economic and political problems that are local, national and global in nature.

The studies of UNEP (United Nations Environmental Programme) indicated that over the preceding 20 years, the problem of land degradation had continued to worsen. The studies further indicated that over-cultivation, overgrazing, deforestation and poor irrigation practices are degrading dry land in every continent. The major factors for this are population (human and livestock) pressures, inappropriate land use and agricultural practices, social conflicts and drought. There was also growing recognition of the part played by human activities and climate change such as prolonged or frequent droughts aggravating land degradation. This led formally defining desertification as “land degradation in Arid, Semi-Arid and Dry Sub-Humid areas resulting from various factors, including climatic variations and human activities” which is used as the basis of the UNCCD (United Nations Convention to Combat Desertification).

Aridity of a region is categorized by the ratio of P = Mean Annual Precipitation to PE = Mean Annual Potential Evapotranspiration, using Thornthwaite formula. The ‘drylands’ are defined as those regions where the ratio of the mean annual precipitation to the mean annual evapotranspiration is in the range of 0.05 to 0.65. It is important to note that CCD considers Arid, Semi-Arid, and Dry Sub-Humid regions as dry land, but excluded Hyper-Arid region, where the P/PE ratio is less than 0.05, from the ambit of the Convention. The Convention also excluded moist Sub-Humid, Humid and Per-Humid zones of various regions in the world. The most important objective of the Convention is to combat desertification occurring in the dryland regions of the world to mitigate the effects of drought.

Desertification is due to complex interactions among physical, biological, social, cultural and economic factors. Desertification impacts the economic growth of not only the affected region, but also of the country as a whole. It also affects the social and economic

development. Desertification and drought affect the sustainable development through their inter-relationships with important social problems such as poverty, poor health and nutrition, lack of food security and consequently results in migration, social conflicts and unrest. The Convention emphasizes the need to address these in an integrated manner.

India became a signatory to the UNCCD on 14 th October 1994 and it came into effect on 17th March 1997 .One of the obligations of all developing country Parties to the Convention, including India, is to prepare the National Action Programme to Combat Desertification and to mitigate the effects of drought.

In the present study, land degradation has been examined with the help of soil moisture status in two different periods. Land degradation would lead to evolve a climate change if any.

2. Methodology

The ratio of precipitation (P) to Potential Evapotranspiration (PE) provides a simple method of estimating the moisture status of a place. If ratio is less than one, it would mean that moisture content of soil in a place is not sufficient to cope with the needs of Evapotranspiration, i.e. the place has dry climate. If the ratio is greater than one, the availability of soil moisture is greater and the climate is humid. Based on this Moisture Index, classification of the regions in different zones such as Arid, Semi Arid and Dry sub Humid etc., has been made.

In the present studies, an empirical criteria for the classification of different zones based upon P/PE ratio viz. Arid (P/PE=0.05-0.20), Semi Arid (P/PE=0.21-0.5) and Dry Sub Humid (P/PE = 0.51-0.65) is used. The two sets of P/PE values have been calculated by considering rainfall normals for the period 1941-1990 for the recent period and the rainfall normals for the period 1901-1950 for the earlier period respectively for different stations in various states of the country. Changes of P/PE values from the earlier period (1901-1950) to recent period (1941-1990) have been examined for the purpose of studying the climate change in different moisture conservation zones and its impact on the land. For the purpose to demarcate the change in P/PE values in the two periods as significant, the difference in P/PE values in two different periods as mentioned above is taken as more than .05. Considering this criteria, the significant change in the ratio P/PE for various stations in different states, in different climatic zones have been identified.

3. Data

The rainfall normals for the period 1901 to 1950 and 1941 to 1990 published by India Meteorological Department have been used for computation of P/PE (Precipitation/Potential Evapotranspiration) for various stations over India and PE values for those stations over India have been used from the publication entitled, 'Potential Evapotranspiration (PE) over India', IMD, Scientific Report No. 136.

4. Results

Based on the moisture index (P/PE) classification of the moisture index over the country has been made in Arid (P/PE = 0.05-0.20), Semi Arid (P/PE = 0.21-0.5) and Dry Sub Humid (P/PE = 0.51-0.65) regions by using rainfall normals for the periods 1901 to 1950 and 1941 – 1990, as shown in Table 1. In the state Rajasthan the districts are in Arid, Semi Arid and Dry Sub Humid regions. In Punjab, the districts are in Semi Arid and Dry Sub Humid region. In Haryana, the region is mostly Semi Arid. In states Gujarat, Maharashtra, Uttar Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu the districts are under Semi Arid and Dry Sub Humid regions. In Madhya Pradesh the region is mostly Dry Sub Humid.

The examination of increase or decrease in P/PE ratio in two periods viz. 1901 to 1950 and 1941 to 1990 shows the results as below:

In Rajasthan the districts Ganganagar, Anupgarh, Bikaner, Jodhpur and Jaisalmer (Arid region), the districts Jhunjhunu, Sikar, Jaipur, Ajmer, Tonk, Sirohi, Pali, Jalore and Churu (Semi Arid region) and districts Sawai Madhopur and Bundi (Dry Sub Humid region) show increase in P/PE ratio. The increase is significant in Sirohi, Jaipur and Sawai Madhopur districts. The districts Kota, Chittorgarh show decrease in P/PE ratio. The districts Barmer, Alwar, Bharatpur, Bhilwara, Udaipur from Semi Arid region show no change.

In Punjab the district Amritsar (Semi Arid region), Gurudaspur, Jalandhar, Ludhiana and Patiala (Dry Sub Humid region) show increase in ratio P/PE with significant increase at Amritsar, Jalandhar, Ludhiana and Patiala. The district Firozepur (Semi Arid region) show significant decrease in the ratio P/PE.

In Haryana the districts Rohtak, Hissar, Gurgaon, Karnal (Semi Arid region) and Ambala (Dry Sub Humid region) show increase in the ratio P/PE with significant increase for Gurgaon and Karnal. In Delhi region (Semi Arid) significant increase in ratio P/PE is observed.

In Gujarat the Kachchh district (Arid region) shows increase in the ratio P/PE. The districts Mahesana, Sabarkantha, Ahmedabad, Jamnagar, Rajkot, Surendranagar, Bhavnagar and Amreli (Semi Arid region), the district Junagadh (Dry Sub Humid region) show increase in the ratio P/PE, with significant increase at Ahmedabad, Amreli, Junagadh and Jamnagar. The district Banaskantha (Semi Arid region), the districts Vadodara, Surat and Panch Mahal (Dry Sub Humid region) show decrease in ratio P/PE. In district Surat significant decrease in ratio P/PE is noticed.

In state Maharashtra the districts Dhule, Jalgaon, Aurangabad, Ahmednagar, Beed, Solapur and Sangli (Semi Arid region), the districts Amravati, Yavatmal, Nanded, Parbhani and Buldhana (Dry Sub Humid region) show increase in the ratio P/PE. The significant increase in ratio P/PE is noticed at Solapur, Sangli, Parbhani and Nanded. The significant decrease in ratio P/PE is observed at Pune. There is no change in the ratio P/PE at districts Akola and Osmanabad (Semi Arid region) and at Nashik (Dry Sub Humid region).

In state Uttar Pradesh the districts Aligarh, Mathura and Kanpur (Semi Arid region), the districts Meerut, Bulandshahar, Agra, Etawah and Jhansi (Dry Sub Humid region) show increase in the ratio P/PE. The significant increase is at Bulandshahar, Aligarh, Meerut, Agra and Etawah. The district Mainpuri (Semi Arid region) shows decrease in the ratio P/PE.

In state Madhya Pradesh the district Bhind (Semi Arid region) and the districts Morena, Gwalior, Datia, Shivpuri, Mandsaur, Jhabua, Dhar, Indore and Ujjain (Dry Sub Humid region) show increase in the ratio P/PE with significant increase at Gwalior, Datia, Bhind and Shivpuri.

In state Karnataka the districts Gulbarga, Bijapur, Raichur, Chitradurga and Mandya (Semi Arid region) and the districts Dharwad, Mysore, Bidar and Bangaluru (Dry Sub Humid region) show increase in P/PE ratio with significant increase at Gulbarga, Bijapur, Raichur and Bidar. The districts Bellary, Tumkur (Semi Arid region) and Hassan (Dry Sub Humid region) show decrease in P/PE ratio with significant decrease at Hassan.

In Andhra Pradesh the districts Ananthapur, Cuddapah, Kurnool, Hyderabad and Nalgonda (Semi Arid region) and Chittoor, Nellore and Warangal (Dry Sub Humid region) show increase in the ratio P/PE with significant increase at Hyderabad, Cuddapah and Nellore. There is no change in P/PE ratio at Guntur (Semi Arid region) and Srikakulam (Dry Sub Humid region).

In Tamil Nadu the districts Madurai and Salem (Dry Sub Humid region) show increase in the ratio P/PE with significant increase at Salem. The district Coimbatore (Semi Arid region) and district Thanjavur (Dry Sub Humid region) show decrease in the ratio P/PE with significant decrease at Coimbatore.

The stations having significant change in the ratio P/PE for the period from 1901-1950 to 1941-1990 are depicted in Table II.

The increase in the P/PE values from the earlier period (1901-1950) to the recent period (1941-1990) shows improvement in the soil moisture availability. There are 35 districts from Semi Arid and Dry Sub Humid region over the country which shows significant increase in soil moisture availability.

The decrease in P/PE values for the two periods as above indicates land degradation due to less soil moisture availability. There are total 18 districts from Semi Arid region (P/PE=0.21-0.5) and Dry Sub Humid region (P/PE=0.51-0.65), which show land degradation. Out of 18 districts, 5 districts show significant land degradation. Fig. 1 shows total land degraded districts and also districts which show significant land degradation.

5. Conclusions

It can be concluded that based on the criteria of moisture index (P/PE) following land degraded districts have been identified in various regions.

i. In Arid region (P/PE=0.05-0.20) no more degradation is noticed.

ii. In Semi Arid Region (P/PE = 0.21-0.5) the districts Firozepur (Punjab), Banaskantha (Gujarat), Pune (Maharashtra), Mainpuri (Uttar Pradesh), Bellary and Tumkur (Karnataka), Coimbatore, Tiruchirappalli, Tirunelveli and Ramanathapuram (Tamil Nadu) show land degradation.

iii. In Dry Sub-Humid region (P/PE = 0.51-0.65) the districts Kota and Chittorgarh (Rajasthan), districts Vadodara, Bharuch, Surat and Panch Mahal (Gujarat), Hassan (Karnataka) and Thanjavur (Tamil Nadu) show land degradation.

iv. There are total 18 land degraded districts over the country from Semi Arid (P/PE = 0.21-0.5) and Dry Sub-Humid region (P/PE = 0.51-0.65). Most significant land degraded parts of the country based on moisture index (P/PE) criteria are Surat (Gujarat), Firozepur (Punjab), Hassan (Karnataka), Pune (Maharashtra) and Coimbatore (Tamil Nadu).

Acknowledgements

We are thankful to AVM Dr. Ajit Tyagi, Director General of Meteorology for encouragement and support. We are also thankful to Dr A. B. Mazumdar, LACD ADGM(R) and Dr A. L. Koppar, DDGM(C) for providing kind support . Thanks are due to Dr. D.S. Pai, for his valuable suggestions. Thanks are also due to Smt. P.R. Iyer for DTP typing. The authors also acknowledge the contributions of DTP unit for designing and printing.

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TABLE – 1
MOISTURE INDEX IN DIFFERENT REGIONS OF INDIA

Arid (P/PE = 0.05-0.20)			**Semi Arid (P/PE = 0.21-0.5)**			**Dry Sub Humid (P/PE = 0.51-0.65)**		
	1901-1950	1941-1990		1901-1950	1941-1990		1901-1950	1941-1990
Rajasthan			**Rajasthan**			**Rajasthan**		
Ganganagar	0.15	0.16	Jhunjhunu	0.27	0.28	Sawai Madhopur	0.51	0.57
Anupgarh	0.11	0.14	Alwar	0.44	0.44	Bundi	0.52	0.53
Bikaner	0.15	0.17	Sikar	0.31	0.33	Kota	0.58	0.54
Barmer	0.15	0.15	Bharatpur	0.39	0.39	Chittorgarh	0.54	0.53
Jodhpur	0.17	0.20	Jaipur	0.31	0.38			
Jaisalmer	0.08	0.09	Ajmer	0.34	0.37			
			Tonk	0.44	0.46			
			Sirohi	0.26	0.37			
			Bhilwara	0.45	0.45			
			Pali	0.23	0.24			
			Jalore	0.22	0.23			
			Churu	0.21	0.24			
			Udaipur	0.45	0.45			
Punjab			**Punjab**			**Punjab**		
			Amritsar	0.37	0.48	Gurudaspur	0.61	0.64
			Firozepur	0.27	0.21	Jalandhar	0.44	0.56
			Bhatinda	-	0.28	Ludhiana	0.48	0.55
						Patiala	0.45	0.52
Haryana			**Haryana**			**Haryana**		
			Rohtak	0.35	0.38	Ambala	0.60	0.64
			Delhi	0.28	0.46			
			Gurgaon	0.38	0.45			
			Karnal	0.36	0.46			
			Hissar	0.23	0.25			
Gujarat			**Gujarat**			**Gujarat**		
Kachchh	0.17	0.21	Mahesana	0.32	0.34	Junagadh	0.41	0.51
			Banaskantha	0.35	0.33	Kheda	-	0.53
			Sabarkantha	0.34	0.35	Vadodara	0.61	0.59
			Ahmedabad	0.37	0.48	Bharuch	0.55	0.53
			Jamnagar	0.27	0.32	Surat	0.95	0.63
			Rajkot	0.27	0.31	Panch Mahal	0.62	0.60
			Surendranagar	0.24	0.25			
			Bhavnagar	0.33	0.34			
			Amreli	0.25	0.31			

TABLE – 1 (contd…)
MOISTURE INDEX IN DIFFERENT REGIONS OF INDIA

Arid (P/PE = 0.05-0.20)		Semi Arid (P/PE = 0.21-0.5)			Dry Sub Humid (P/PE = 0.51-0.65)		
1901-1950	1941-1990		1901-1950	1941-1990		1901-1950	1941-1990
Maharashtra		**Maharashtra**			**Maharashtra**		
		Dhule	0.33	0.37	Amravati	0.49	0.53
		Jalgaon	0.39	0.41	Nashik	0.61	0.61
		Akola	0.49	0.49	Yavatmal	0.56	0.57
		Aurangabad	0.41	0.43	Nanded	0.54	0.59
		Ahmednagar	0.36	0.38	Parbhani	0.50	0.56
		Beed	0.39	0.41	Buldhana	0.49	0.52
		Pune	0.78	0.49			
		Solapur	0.32	0.42			
		Sangli	0.39	0.45			
		Osmanabad	0.49	0.49			
Uttar Pradesh		**Uttar Pradesh**			**Uttar Pradesh**		
		Aligarh	0.43	0.50	Meerut	0.46	0.59
		Mainpuri	0.50	0.47	Bulandshahar	0.46	0.51
		Mathura	0.40	0.44	Agra	0.45	0.59
		Kanpur	0.48	0.49	Etawah	0.42	0.57
					Jhansi	0.58	0.61
Madhya Pradesh		**Madhya Pradesh**			**Madhya Pradesh**		
		Bhind	0.42	0.47	Morena	0.48	0.52
					Gwalior	0.50	0.57
					Datia	0.50	0.57
					Shivpuri	0.55	0.61
					Mandsaur	0.51	0.53
					Jhabua	0.50	0.53
					Dhar	0.59	0.61
					Indore	0.54	0.56
					Ujjain	0.55	0.56
Karnataka		**Karnataka**			**Karnataka**		
		Gulbarga	0.37	0.43	Dharwad	0.50	0.54
		Bijapur	0.33	0.39	Mysore	0.50	0.51
		Raichur	0.31	0.37	Hassan	0.74	0.62
		Bellary	0.33	0.30	Bidar	0.52	0.57
		Chitradurga	0.36	0.38	Bangaluru	0.53	0.55
		Tumkur	0.39	0.36			
		Mandya	0.43	0.44			

TABLE – 1(contd…)
MOISTURE INDEX IN DIFFERENT REGIONS OF INDIA

Arid (P/PE = 0.05-0.20)		**Semi Arid (P/PE = 0.21-0.5)**			**Dry Sub Humid (P/PE = 0.51-0.65)**		
1901-1950	1941-1990		1901-1950	1941-1990		1901-1950	1941-1990
Andhra Pradesh		**Andhra Pradesh**			**Andhra Pradesh**		
		Guntur	0.49	0.49	Chittoor	0.49	0.51
		Prakasam	-	0.43	Srikakulam	0.63	0.63
		Ananthapur	0.29	0.30	Nellore	0.55	0.60
		Cuddapah	0.37	0.42	Warangal	0.61	0.65
		Kurnool	0.34	0.38			
		Hyderabad	0.43	0.50			
		Nalgonda	0.38	0.40			
Tamil Nadu		**Tamil Nadu**			**Tamil Nadu**		
		Coimbatore	0.53	0.38	Madurai	0.51	0.52
		Tiruchirappalli	0.42	0.41	Salem	0.49	0.54
		Tirunelveli	0.45	0.44	Thanjavur	0.53	0.51
		Dharmapuri	-	0.50			
		Ramanathapuram	0.50	0.46			

TABLE II
Stations having significant change in the ratio P/PE from 1901-1950 to 1941-1990 period

RAJASTHAN		GUJARAT		PUNJAB	
Sirohi	I	Ahmedabad	I	Amritsar	I
Jaipur	I	Amreli	I	Jalandhar	I
Sawai Madhopur	I	Junagadh	I	Ludhiana	I
		Jamnagar	I	Patiala	I
		Surat	D	Firozepur	D
HARYANA		**KARNATAKA**		**MAHARASHTRA**	
Delhi	I	Gulbarga	I	Solapur	I
Gurgaon	I	Bijapur	I	Sangli	I
Karnal	I	Raichur	I	Parbhani	I
		Hassan	D	Nanded	I
		Bidar	I	Pune	D
UTTAR PRADESH		**MADHYA PRADESH**		**ANDHRA PRADESH**	
Bulandshahar	I	Gwalior	I	Hyderabad	I
Aligarh	I	Datia	I	Cuddapah	I
Meerut	I	Bhind	I	Nellore	I
Agra	I	Shivpuri	I		
Etawah	I				
TAMIL NADU					
Salem	I				
Coimbatore	D				

Legend: "I/D" significant increase/decrease in P/PE from the period (1901-1950) to recent period (1941-1990)

FIG.1: REGIONS SHOWING LAND DEGRADATION BASED ON MOISTURE INDEX (P/PE) CRITERIA