WTCER

Concept Paper

PUBLICATION NO. 8

MAJOR ISSUES RELATED TO RAINWATER MANAGEMENT IN SUB-HUMID AND HUMID REGIONS

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INTRODUCTION

Rainfall is the main source of water supply to soil profiles, ground water and surface reservoirs in the hydrologic cycle. So far rainwater management has been limited to arid, semiarid and upto some extent subhumid (dry) areas mainly for raising rainfed crops. In subhumid, humid and perhumid areas, rainwater management has got little emphasis, that too, for soil and water conservation in micro-watersheds. However, it has totally been neglected in irrigated (canal and tubewell command) areas resulting waterlogging, soil salinity, lowering/raising of ground water level etc. No adequate emphasis has been given, so far, to rainwater management in rainfed waterlogged areas.

India's assured rainfall areas falling under subhumid, humid and perhumid agro-climatic regions (Figure 1) are blessed with good natural resources, particularly water. Sometimes this blessing of rainfall becomes a curse to the people due to large variation in its occurrence and intensity resulting floods and/or droughts. Although human beings cannot check/change/reverse mighty hydrological cycle (*Jal Dewta), they* can certainly manage (pray) to regulate (please) the hydrologic cycle (*Jal Dewta*) to reduce hazards of floods and droughts.

> ***"No grain is ever produced without water, but too much water tends to spoil the grain. An inundation is as injurious to growth as dearth of water"***
>
> ***-Narada Smriti, XI,19***

About 160 M ha m of rainwater is flowing through rivers and draining in sea every year. It means about 40% of annual rainwater is wasted, mostly in these regions.

Rainwater management has become crucial for agricultural production system in irrigated as well as rainfed situations of this assured rainfall regions. A time has now come to treat rainwater management as a pre-requisite for adoption of improved agricultural practices for sustainability of improved practices and agricultural production. Rainwater management problems are more complex in these regions as compared to arid and semi-arid regions because of fragile physiographic and socio-economic conditions and erratic rainfall pattern in times and space.

It is possible to develop appropriate rainwater management strategies in conjunction with irrigation systems in these regions for increasing productivity of lands by 100 to 200 per cent on sustainable basis using bottom up approach.

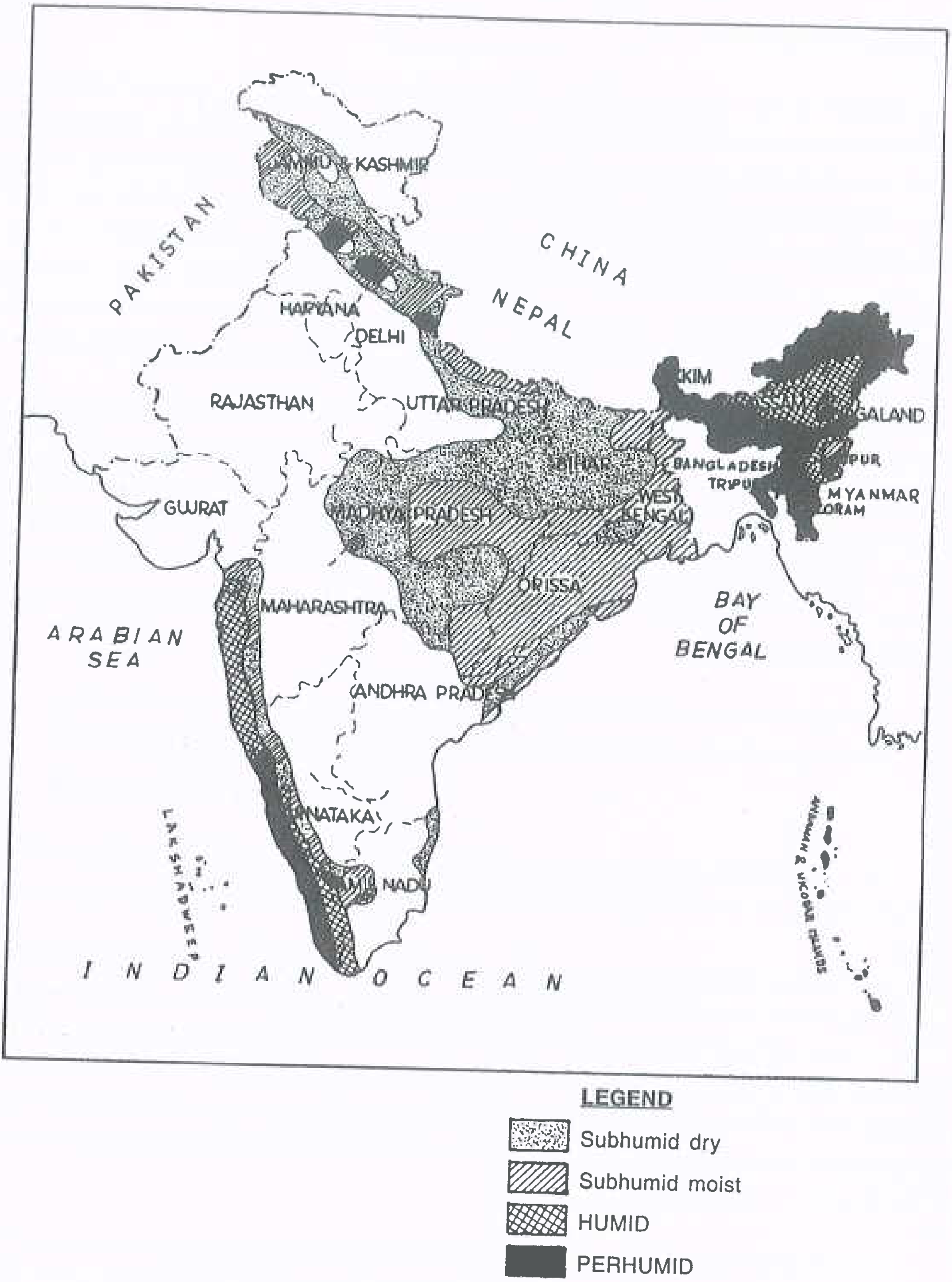

Fig.1 : Subhumid, Humid and Perhumid Regions of India.

CHARACTERISATION OF THE AGRO-CLIMATIC REGIONS

It is very difficult to exactly divide/demarcate the areas requiring different sets of rainwater management strategies. Based on droughts and flood problems, the areas receiving mean annual rainfall above 1200 mm covering 28% of geographical area are prone to floods, soil erosion and face drought during post monsoon season (Table 1).

Table 1: Major problems of different rainfall zones

Means Annual Rainfall, mm	Percentage Area Covered	Major Problems
Less than 750	30	Drought
700-1200	42	Drought/flood
1200-2000	20	Flood/drought
Above 2000	8	Flood/drought

According to another classification of rainfall regions (Table 2), areas receiving more than 1150 mm mean annual rainfall is termed as high rainfall region which cover about 1/3 of the country (eastern region, Kerala, coastal Karnataka, Konkan region of Maharashtra and south Gujrat). Rice is grown in 90% of this region during kharif. Total monsoon rainfall even in the worst drought year is sufficient to have a good crop, if it is managed well.

Table 2: Rainfall regions of India

Regions	Average Annual Rainfall, mm
Very low rainfall regions	<500
Low rainfall regions	500-750
Medium rainfall regions	750-1150
High rainfall regions	>1150

Bioclimatic classification (Table 3) indicates that subhumid, humid and perhumid regions receive adequate rainfall to grow at least two crops in a year maintaining cropping intensity above 200% through proper management of rainwater in situ, water harvesting systems and surface and ground water irrigation systems.

The details of agro-ecological sub-regions falling in subhumid, humid and per-humid ecosystems of our country is given in Annexure I (Velayutham et al, 1999).

Table 3 : Bioclimatic classes and their limits

Bioclimatic Class	Length of Growing Period	Moisture Index (Mather 1956)	Annual Rainfall, mm
Arid	**0-90**	**<-66.7**	**<150-500**
Hyper arid *	0-60	<-83.3	<150
Typic arid	60-90	-66.7 to –83.2	150-500
Semi-arid	**90-150**	**-33.3 to –66.6**	**500-1000**
Semi arid dry	90-120	-50.0 to –66.6	500-750
Semi arid moist	120-150	-33.4 to –49.9	750-1000
Sub humid	**150-240**	**20 to –33.3**	**1000-1600**
Subhumid dry	150-210	0 to –33.3	1000-1200
Subhumid moist	210-240	0 to +20	1200-1600
Humid	**240-330**	**+20 to +100**	**1600-2000+**
Perhumid	**>330**	**> +100**	**>2500**

*Including cold arid

Source: Velayutham et al, 1999.

Based on agricultural science and technology research needs subhumid, humid and perhumid plain and submontane regions can be called green areas having enough water available but green revolution has not occurred in all these areas (Table 4). Water management needs top priority in these areas. It is the next region where green revolution is expected through rainwater management and conjunctive use of rainwater, surface water and ground water.

Table 4: Science and Technology zones based on research needs for various growing conditions (Swaminathan 1989)

Sl. No.	Zones
1.	Green revolution area
2.	Green but no green revolution area
3.	Semiarid areas
4.	Arid areas
5.	Montane areas
6.	Coastal zone
7.	Islands

MAJOR ISSUES

1. Exclusion of Coastal and Island Ecosystem

Coastal areas and Islands falling under subhumid and humid eco-regions have different problems mainly related to sea water intrusion. These areas require different sets of rainwater management technology. Thus, it may be excluded from this programme and taken up separately.

2. Flood control

Major floods are associated with mighty Ganga and Brahmaputra rivers. Other rivers prone to floods are mostly in subhumid and humid regions. Total flood affected area is about 40 M ha and every year 8-10 M ha area is affected by flood. Net crop damage every year due to flood is 3-5 M ha. Main causes of floods in our country are 1) incessant rain in catchment areas of rivers resulting peak discharge over the carrying capacity of the rivers; 2) persistent deposition of sediments on the riverbeds reducing their carrying capacity, and 3) planned release or breaches of reservoirs. The flood control measures adopted, so far, in these regions are construction of multipurpose reservoirs with one of the objectives to moderate floods and constructing embankments for protecting towns and cities. The major reservoirs are facing problems of silting at alarming rate.

> *–Development and adoption of appropriate rainwater management technology including soil and water conservation measures and multipurpose water harvesting systems in series on watershed basis for flood control and checking fast silting of reservoirs should be taken up on priority.*

3. Irrigation Expansion and New Irrigation Projects

Main criterion for constructing reservoir systems has so far been the availability of sites and not the need of irrigation. All good sites have been built up and the new sites are going to face more challenging technical and social problems. There are different opinions about having small reservoirs and tanks/ponds in place of large reservoirs without causing damages to forest and agricultural land and displacement of people. Small reservoirs/ponds cover 10 to 15 times more area due to low depth of water which is also a great concern. Increasing cost of surface irrigation system is another concern which has reached above Rs 90,000 per ha of irrigated area.

Most of these regions are rich in ground water which is largely untapped. It has to be utilised judiciously as rising ground water is creating waterlogged situation in some parts and over exploitation causing lowering of ground water table in some parts.

–Development of technology for locating and designing large and small reservoirs in combination with ground water irrigation system for balanced irrigation/recharge is needed for sustainability of the irrigation systems.

4. Rainwater Management – a Pre-requisite for Rainfed as well as Irrigated Farming

The emphasis on rainwater management has so far been limited to rainfed farming for in situ rainwater conservation and water harvesting for life saving irrigation particularly in arid and semiarid regions. Subhumid and humid regions have got little attention in respect of rainwater management, that too, for soil and water conservation. Adequate irrigation water supply has been one of the reasons for green revolution in major parts of Punjab and Haryana which is now subjected to lowering ground water table in absence of proper rainwater management. Sustainability of our irrigation systems is facing following problems:

1. Declining water table in tube well irrigated areas due to over exploitation of ground water,
2. Rise of water table causing waterlogging/salinization in canal commands due to low efficiency of canal system and misuse of water by the farmers,
3. Tail end deprival of irrigation water in canal commands.

–In situ rainwater management practices should be adopted in irrigated areas for sustainability of irrigation system with higher efficiency. It will result in:

- *i) More ground water recharge and lesser irrigation needs*
- *ii) Increase in command area*
- *iii) Controlling tail end deprival*

5. Mitigation of Waterlogged Condition

Sizable agricultural land of these regions are seasonally waterlogged during monsoon due to one or other reasons and their productivity is thus very poor because of unfavourable edaphic environment. The major waterlogged situations are:

1. Waterlogging in canal command due to seepage from canal
2. Under exploitation of ground water and rising water table in some pockets
3. Lowlands having no surface drainage points

- *Development of appropriate technology for drainage in waterlogged areas.*
- *Development of appropriate technology to mitigate waterlogged situation where no drainage points are available by:*

  i) Changing land configuration for reducing water depth for growing crop and creating pond for fish production & supplemental irrigation.

  ii) Recycling through open wells

  iii) Development of appropriate technology for judicious use of ponded water.

6. Dynamic, Location-Specific, Appropriate Technology

Piece meal information (technology) related to water harvesting tanks, percolation tanks and wells, soil erosion control, in situ rainwater management, rainfed crops and supplemental irrigation are available. It is now required to develop integrated approaches and mathematical models with appropriate mix of different technologies to maximise agricultural production on sustainable basis. Any new technology adopted becomes traditional and after few years it further requires improvement. In the past this process has been very slow; presently it is fast. Stepwise bottom up approach of adopting new technology is sustainable but it requires systematic design in view of certain phenomenal changes going on to get steady growth of farming keeping pace with population growth. Development and adoption of people participation technology in developing rainwater management system are also required.

- *Development of dynamic, location-specific appropriate technology packages (sustainable technology packages) on rainwater management is needed for integrated watershed development and management including rainwater management in situ and in surface and ground water reservoirs and its conjunctive use following bottom up approach.*

7. Rainwater Harvesting for Life Saving/Protective/Full Irrigation

Rainwater harvesting in tanks/ponds has been a century old practice for water supply to domestic and cattle needs and irrigation when there was no modern methods for water supply and irrigation. Recently more research efforts have renewed interest in the tank technology in arid and semiarid areas. Presently, a lot of information/ recommendations is available on tank based water harvesting system for these areas. Despite positive efforts, adoption of tank technology by the farmers is very poor in arid and semi-arid areas due to following reasons:

1. Value/productivity of land under tank is generally not considered while analysing cost of the system.

2. There is no viable system for operation and maintenance when tank is constructed on common land.

3. There is no economically viable methods for seepage and evaporation control.

4. Tanks are normally designed to harvest all excess rainwater for a protective irrigation to rainfed crops where drip/sprinkler can not be used with the system and over all tank yield efficiency is about 40-50 per cent.

–In subhumid and humid regions it is possible to design multipurpose tanks in series with 100 to 200 per cent water yield capacity for full irrigation in conjunction with in situ rainwater conservation.

8. Harvesting of Subsurface Water/Springs

Most of the subhumid, humid and perhumid ecosystems have numerous perennial subsurface water stream which can very easily be harvested by making check dams (in big streams) and storage tank. Various types of water harvesting models are available for harvesting subsurface flow and utilising the same for irrigation. There is a great scope to select/design low cost water harvesting system according to location specific situations.

–Development of appropriate systems for harvesting subsurface water flow for irrigation should be taken up on priority.

9. Conjunctive and Versatile use of Water Harvesting Systems

To increase productivity of land and agricultural production water harvesting tanks should be designed with canal or well/tubewell system for conjunctive use and for mitigating hazards of soil salinity and poor quality ground water. It may be designed for versatile use of stored rainwater using consumptive and non-consumptive multiple productive system to produce fish, manure, duck in tanks and horticultural trees/vegetables on embankment and crops around the tanks.

–Design tanks in conjunction with canal and wells for versatile use of collected water.

10. Watershed, Irrigation Water Resources and their Command Areas as a Unit System

Scientifically, in hydrologic term watershed, surface/under ground water reservoirs and their command areas are a unit system as these three components of hydrologic cycle are interdependent. Presently different agencies/departments are managing these components as independent units without active integration resulting in very low efficiencies of water management works. A multidisciplinary team/organisation/department can very easily and efficiently manage these components as a unit system for maximum possible use of rainwater on sustainable basis maintaining ecology of the system.

–Watershed, surface/underground water reservoirs and their command areas should be treated as a single unit for comprehensive rainwater management.

11. Development and Monitoring of Model Watersheds

Truly speaking, the only difference in currently ongoing watershed development/management programme and other previous programmes on the development of agriculture is the name, because the application of watershed principles and active integration are still missing under watershed development programme. A review of ICAR-managed watersheds has clearly indicated that development of water resources, whether from surface or recharge of ground water through rainwater management, works as catalyst for adopting modern agricultural technology. In any agro-climatic zone there is no completely developed model watershed for demonstration and training and its replication for developing the region. For planning watershed development programmes in future, there is an urgent need to monitor watershed behaviors for longer duration under different treatments to create data base.

–In each agro-ecological sub region following two types of model watershed should be developed and monitored:

1. *Replicable model: for demonstration, training and development of the region.*
2. *Long Term Study Model: to monitor hydrological and other behavior of watershed for dynamic planning and development of watershed in future.*

12. Lessons from not only Success Stories but Failures too

Rainwater management in these regions are more complex and challenging. Each technology should be viable (practically & economically) and fit in the whole agricultural, social and overall ecological system on sustainable basis. Most of our success stories related to rainwater management are not spreading/moving/replicating fast because of certain limitations/weaknesses which we hide due to obvious reasons. If we are really interested in developing viable and sustainable rainwater management systems we have to learn deeply the failures and weak points/side effects of success stories. Success, failure and weak points should be published and debated alike for developing appropriate/viable and sustainable rainwater management technology in these regions.

13. Human Resource Development

In view of weak coordination and integration among development workers belonging to watershed, water resource and command area development programme and lack of interdisciplinary training in the field of water management, suitable and adequate manpower is not available to take up rainwater management programme.

–Multi-disciplinary training programme is required to develop adequate manpower.

–Institution/department/agency is required for planning, executing and maintaining rainwater management works with active participation of the farmers.

In order to meet the increasing food demands and to control floods, waterlogging and soil erosion in subhumid and humid regions it has become essential to launch a research programme in view of above discussed issues to develop appropriate technology on rainwater management with following objectives:

1. To increase crop intensity upto 200%
2. To achieve food grain productivity of land upto 6-7 t/ha/year
3. To control floods, waterlogging, soil salinity and soil erosion
4. To increase fodder, fuel wood, timber, fruit and fish production by 2 to 3 times
5. To bring green revolution in the region

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Annexure-I

Details of Agro-ecological Subregions in Subhumid, Humid and Perhumid Ecosystem

Description of Sub region	Location	Area M ha	LGP (day)	Major Soil Group	Rainfall mm	PET mm	Mean Temp. °C	Cropping intensity %
1	2	3	4	5	6	7	8	9
Northern plains (Punjab and Rohilkhand Plain), hot dry, subhumid with alluvium soils	**Punjab:** Gurdaspur*, Hoshiarpur, Jalandhar, Rupnagar, Ludhiana and Patiala* **Union Territory of Chandigarh** **Haryana:** Ambala **U.P.:** Saharanpur, Bijnor, Moradabad*, Muzaffarnagar*	3.9	120-150	Haplustalfs Rhodustalfs Pellustalfs Ustorthents	700-1000	1300-1500	24-26	164
Northern (Riohilkhand Plain, Avadh Plain and S. Bihar Plain), hot dry subhumid ecosystem with alluvium-derived soils	**U.P.:** Rampur, Barelly, Pilibheet, Shajahanpur*, Lakhimpur (Kheri)*, Sitapur, Lucknow, Barabanki, Faizabad, Sultanpur, Azamgarh, Ballia, Ghazipur, and Varanasi* **Bihar:** Bhojpur (Ara), Rohtas (Sasaram), Jahanabad, Patna, Bihar-Sariff (Nalanda), Aurangabad, Gaya, Nawada	8.3	150-180	Ustochrepts Ustifluvents Natrustalfs	1000-1200	1300-1500	25-26	172
Central Highlands (Malwa Plateau, Bundelkhand uplands) hot dry subhumid eco-ystem with deep black soils (Shallow and medium black soils as inclusion)	**M.P:** Guna, Sagar, Bhopal, Damoh, Vidishi, Rajgarh, Shajapur, Sehore, Raisen, Jabalpur*, Narsimpur and Hoshangabad	8.1	150-180	Ustochrepts Halaquepts Natrustalfs Haplustalfs Ocharaqualfs Haplaquepts Ustorthents	1000-1500	1400-1600	24-25	107

1	2	3	4	5	6	7	8	9
Deccan (Satpura) Plateau, hot dry subhumid eco-system with deep black soils (shallow and medium deep black soils as inclusion)	**M.P.:** Betul **Maharashtra:** Wardha, Nagpur & Chandrapur*	2.8	150-180	Ustoochrepts Chromusterts Ustorthents Rhodustalfs Haplustalfs	1000-1200	1300-1500	25-26	110
Central Highlands (Vindhyan Scarpland and Bundelkhand Upland), hot dry subhumid eco-system with mixed Red and Black soils	**M.P.:** Tikamgarh, Chhatarpur, Panna, Satna, Rewa, Sidhi, Shandol	5.8	150-180	Ustorthents Ustochrepts Chromusterts Haplustalfs Rhodustalfs	1000-1200	1400-1500	25-26	117
Deccan (Satpura range and Maharashtra) Plateau, hot moist subhumid eco-system with Red and Black soils	**M.P.:** Chandwara, Seoni, Mandia, Balaghat, Jabalpur*, Narsimpur and Hoshangabad **Maharashtra:** Bhandra	5.6	180-210	Ustochrepts Chromusterts Ustorthents Haplustalfs Paleustalfs Plinthustalfs	1100-1500	1400-1600	24-25	119
Eastern (Baghelkhand and Chhotanagpur) Plateau, hot dry and moist subhumid ecosystem with Red and Yellow soils	**U.P.:** Mirzapur **Bihar:** Palamu (daltonganj), Hazaribag, Gumla, Lohardaga **M.P.:** Ambikapur, Bilaspur, Raigarh, Raipur, Rajnagaon, Durg	14.1	150-180	Ustorthents Ustochrepts Haplustalfs Rhodustalfs	1200-1600	1400-1600	25-28	127

1	2	3	4	5	6	7	8	9
Eastern (Gujarat Hills, Dandakaranya) Plateau, hot moist subhumid ecosystem with Red and Lateritic soils	**Maharashtra:** Chandrapur, Gadchiroli **M.P.:** Bastar (Jagdaipur) **Orissa:** Koraput, Kalahandi (Bhawanipatna), Phulbani, Bolangir, Sambalpur, Sundergarh, Dhenkanal, Mayurbhanj (Baripada)	17.6	180-210	Ustochrepts Ustorthents Haplustalfs Rhodustalfs Chromusterts Haplaquepts Plinthustalfs	1400-1700	1400-1600	26-27	110
Eastern Ghat, hot moist subhumid ecosystem with Red and Lateritic soils	**A.P.:** Western highlands of Vishakhapatnam, Vizianagarm **Orissa:** Westen highlands of Ganjam (Chhatrapur), Puri (Bhubaneswar), Cuttack and Baleshwar (non-coastal part)	3.3	180-210	Haplustalfs Ustochrepts Haplaquepts Ustifluvents Plinthustalfs Rhodustalfs Haplustalfs Ustorthents Chromusterts	1200-1600	1400-1600	25-27	133
Eastern (Chhotanagpur) Plateau and Gujarat Hills hot dry subhumid eco-system with Red and Lateritic soils	**Bihar:** Dumka, Devghar, Giridih, Dhanbad, Ranchi, Singhbum (Chaibasa) **West Bengal:** Birbhum,Bankura, Bardhman and Medinipur* (Siuri, Simlapal, Asansol, Jhargram subdivision, respectively) Puruliya **Orissa:**Kendujhargarh (Kendujhar)	5.6	150-180	Ustorthents Haplustalfs Rhodustlafs Haplustults Haplaquepts Ustochrepts Occhraqualf	1200-1500	1400-1600	25-26	112
Eastern (North Bihar and Avadh) Plain, hot dry to moist subhumid ecosystem with alluvium-derived soils	**U.P.:** Bahraich, Gonda, Gorakhpur and Deoria **Bihar:** Paschim Champaran (Bettiah) Purab Champaran (Motihari), Gopalganj, Siwan, Sitamari, Muzaffarpur, Chhapra (Saran), Madhubani, Darbhanga,	9.9	180-210	Paleustalfs Haplustalfs Ustorthents Ustochrepts Haplaquepts Haplaquents Udifluvents	1200-1500	1400-1700	24-25	150

1	2	3	4	5	6	7	8	9
	Samastipur, Saharsa, Begusarai, Munger, Khagaria, Sahibganj, Bhagalpur, Katihar, Madhepura, Purnia, Hazipur, Godda			Pssamaquents				
Central Himalayas, Warm to hot moist subhumid ecosystem with Tarai soils	**U.P.:** Foothils in Kheri and Baiharich, Pilibheet, Gonda, Basti, Gorakhpur	1.2	180-210	Ustifluvents Ustochrepts Hapludalfs Haplaquoll Utochrept	1400-1500	1400-1600	20-24	165
Western (Kashmir) Himalayas, warm semi-arid to dry humid ecosystem with skeletal soils	**J&K:** Tribal Territory, Chilas, Gilgitwazarat, Srinagar*, Udhampur*, Baramulla* **H.P.:** Northern parts of Chamba, Kullu, Lahaul and Spiti (Keylong)* Kalpa (Kinnaur)	6.0	90-120	Hapludolls Haplaquepts Fluvaquents Udifluvents Eutrochrepts Haplustalfs Udorthents	500-600	800-900	8-10	
South Kashmir & Kumaun Himalayas, warm to hot dry to moist subhumid ecosystem with Brown Forest and Podzolic Soils	**J&K:** Muzaffarbad, Baramulla* Punch, Mirpur, Srinagar*, Anantnag, Raisi, Jammu, Udhampur*, Kathua **Punjab:** Northern wedge (Siwalik foothills) of Gurdaspur and Hoshiarpur **H.P.:** Southern part of Chamba, Una (Hamirpur), Solan, Bilaspur, Nahan, Kullu*, Dharamshala* **U.P.:** Dehradun*, Uttar Kashi*, Narendranagar (tehri Garhwal)*, Gopeswar (Chamoli), Almora, Pithoragarh	12.7	180-210	Eutrochrepts Ustorthents Hapludalfs Hapludalfs Hapludolls Argiudolls Udifluvent Haplaquepts	600-1300	800-1000	15-20	164

1	2	3	4	5	6	7	8	9
Punjab Himalayas, warm humid and perhumid ecosystem with brown forest and Podzolic soils	**H.P.:** Dharamsala, Mandi, Shimla, Bilaspur	1.0	270-300	Hapludalfs Eutrochrepts Udorthents Dystochrepts	2000-2500	800-1000	15-18	164
Kumaun Himalayas, warm perhumid to perhumid ecosystem with red and yellow soils	**U.P.:** Dehradun*, Uttar Kashi*, Tehri Garhwal*	0.5	270-300	Ustorthents Udorthents Eutrochrepts Dystrochrepts Hapludalfs	2000-2500	800-1000	3-30	148
Foothills of Kumaun Himalays (subdued), warm perhumid/perhumid ecosystem with Tarai soils	**U.P.:** Pauri Garhwal, Nainital	0.9	210-240	Hapludolls Eutrochrepts	2000-2600	800-1000	14-15	168
Eastern plain (Ganga Plain) hot moist subhumid ecosystem with alluvium-derived soils	**West Bengal:** West Dinajpur (Balurghat), Maldah, Murshidabad (Behrampur), Krishnanagar, Hoogli, North 24-Parganas, Howrah, Calcutta, Medinipur*, Bankura, Bardhaman and Birbhum	5.2	210-240	Ustochrepts Eutrochrepts Ochraqualfs Haplaquepts Ustifluvents Haplustalfs Dystrochrept Udifluvents	1300-1600	1400-1600	25-26	138
Bramhaputra plain, hot humid ecosystem with alluvium-derived soils	**Assam:** Barpeta, Kamrup, Nalbari*, Darrang (Mangaldoi), Sonipur (Tezpur), Nagpur	3.2	240-270	Haplustalfs Ustochrepts Ustorthents Udifluvents Udipsamments Haplaquepts	1600-2000	1400-1600	24-25	130

1	2	3	4	5	6	7	8	9
Assam and Bengal Plain (Testa Valley and Barak valley), hot perhumid eco-system with alluvium derived soils	**West Bengal:** Jalpaiguri (Plain), Koch Bihar **Assam:** Golpara, Dhubri, Kokrajhar (Plain), Silchar, Karimgunj **Tripura:** Northern part of Dharmanagar	1.4	270-300	Haplaquepts Udifluvents Hapludalf Fluvaquent	2000-3200	1400-1600	24-25	147
Assam and Bengal Plain (Upper Bramhaputra Valley), warm to hot perhumid ecosystem with alluvium derived soils	**Assam:** Jorhat, Golaghat, Sibsagar, Dibrugarh, Northern plain of Kabir Anglong, Northern Lakhimpur	2.3	>300	Dystocrept Kandihumult Haplohumult Hapludalfs Fluvaquents Haplaquepts	2500-3000	1400-1600	23-24	110
Eastern Himalayas, warm perhumid ecosystem with Tarai soils	**West Bengal:** Foothills of Siliguri and Jalpaigur **Assam:** Foothills of Kokrajhar, Barpeta, Nalbari and Darrang (Mangaldoi)	0.3	>300	Umbrept Dystochrept Udorthent	2600-3000	800-1000	23-24	
Eastern Himalayas (Darjeeling & Sikkim), warm perhumid ecosystem with Brown and Red hill and Podzolic soils	**West Bengal:** Darjeeling (subdivision of Darjeeling distirct) **Sikkim:** North, South, East and West Sikkim	1.1	>300	Udorthents Dystrochrepts Haplumberept Eutochrepts	2500-3000	800-900	13-15	142
Eastern Himalayas (Arunachal Pradesh), warm to hot perhumid	**Arunachal Pradesh:** Bomdsila (W. Kameng), Seppa (East Kameng), Lower Subansiri (Zirol, Upper Subansiri (Daporijo),	8.2	>300	Udorthents Hapludulfs Dystrochrepts Paleudalfs	>3000	800-1000	15-25	164

1	2	3	4	5	6	7	8	9
ecosystem with Red loamy soils	W. Sing (Along), E. Siang (Pasighat), Dibang Valley (Anini), Lohit (Tezu)			Haplumbrepts				
Eastern range (Meghalaya Plateau and Nagaland hill), warm to hot perhumid ecosysterm with red and lateritic soils	**Meghalaya:** W. Garo hill (Tura), E. Garo hills, E. Khasi hill (Shillong), Nongstain, Jowai **Assam:** N. Cachchar (Haflong), Karbi-Anglong (Diphu) **Nagaland:** Kohima, Phek, Zunhebhto, Eastern part of Wokha Mokakchung, Thensung, Hon. **Arunachal Pradesh:** Tirup (Khonsa)	5.1	270-300	Dystrochrepts Hapludults Hapludalfs Paleudalfs Paleudults Hapludolls	>2500	1400-1600	16-24	114
Eastern range (Purvachal), warm to hot perhumid ecosystem with Red and Yellow soils.	**Manipur:** Senapati (Karong), Ukhrul, Imphal, Churachandpur, Tamenglog, Thoubal (Chandel) **Mizoram:** Aizwal, Lungile, Lawngthi **Tripura:** W. Agartala, Dharmanagar*, Udaipur*	5.5	>300	Dystrochrept Hapludalfs Hapludults Peleudalfs	>3000	1400-1600	16-25	142

***Indicates parts, i.e., northern, southern, eastern or western.**