

Problems of Soil Erosion and Achievements in India

1.1 Problems

Soil-water-plant resources are nature's gift to mankind. Overgrazing, deforestation, faulty cultivation (Plate 1 to 3), shifting cultivation and carelessly built roads in the catchment areas, have led to devastating effects downstream. These include gully-ing and floods leading to destruction of farm lands and villages; drop in flow during the dry season and consequent loss of crops; and siltation of reservoirs and canals. The problem has been further aggravated due to high rate of population growth—both, human and livestock, resulting in indiscriminate exploitation of natural resources, for meeting the ever-increasing demand for food, fodder, fuel, fibre and fertilizers. Thus continuous degradation of production base and imbalance in land-water-plant, human-animal systems is leading to ecological imbalance and economic insecurity, through severe soil erosion, both by water and wind and threat to the quality of our life and cultivation.

Even though no systematic survey for ascertaining the extent of various problem areas in the country has so far been conducted, it is estimated (Das, 1985) that out of a total reported geographical area of 329 m ha, about 167 m ha (about 51% of total) are affected by serious water and wind erosion, erosion due to shifting cultivation and erosion of culturable wastelands (Table 1.1).

The forms of soil erosion by water are sheet erosion (4–10 tonne/ha/year in red soil, 17–43 tonne/ha/year in black soil and 4–14 tonne/ha/year in alluvial soils), gully erosion (about 33 tonne/ha/year in ravine regions), hill side erosion (more than 80 tonne/ha/year in landslide, mine spoil areas, etc.), and stream bank erosion. (Plate 4 to 7).

In a recent analysis of annual soil erosion rates in India (Dhurva and Ram Babu, 1983), it was estimated that about 5334 m tonne (16.35 tonne/ha) of soil is detached annually due to agriculture and associated activities alone. The country's rivers carry about 2052 million tonnes (6.26 tonne/ha) of this, nearly 1572 m tonne (29% of the total eroded soil) are carried away by the rivers into the sea every year and 480 m tonne (10% of the total eroded) are being deposited in various reservoirs, resulting in the loss of 1 to 2% of the storage capacity.

The estimated 167 m ha of total problem areas includes about 127 m ha, subject to serious soil erosion and 40 m ha degraded through gully and ravines, shifting cultivation, water-logging, salinity, alkalinity, shifting of river courses, desert area, etc. (Tables 1.2, 1.3 and 1.4).

1.2 Achievements

India can be counted among the foremost nations in the third world to have taken note of these serious problems of soil erosion and land degradation, with the beginning of the planned development in India in 1951.

Table 1.1 *Distribution of problem areas due to soil erosion under various land utilization classes and different types of land degradations (Das, 1985)*

(Area - m ha)			
Soil erosion in land utilization classes	With 1981-82 data		Remarks
	Total area	Problem area	
1.0 <i>Cultivated land</i>			
1.1 Rainfed non-paddy	77.88	77.88	Rainfed Non-paddy-Net sown (Net irrigated + Upland paddy)
1.2 Current fallows	13.48	3.37	
1.3 Fallows other than current fallows	9.56	4.78	
1.4 Permanent pastures grazing land	12.01	4.16	
1.5 Misc. tree crops and groves	3.62	0.72	
1.6 Cultivable wasteland	16.41	8.29	
Sub-total of 1.0	132.96	99.20	
2.0 <i>Forest Land</i>			
2.1 Reserve forest	39.01	3.90	
2.2 Protected forest	23.21	9.28	
2.3 Unclassed forest	12.63	6.31	
Sub-total of 2.0	74.85	19.49	
3.0 <i>Area not available for agriculture and not under forest</i>			
3.1 Non-agricultural use	19.51	3.90	
3.2 Barren and unculturable	20.22	4.03	
Sub-total of 3.0	39.73	7.93	
4.0 <i>Degraded lands</i>			
4.1 Gullies and Ravines	3.98	3.98	Table lands not included
4.2 Shifting cultivation	4.36	4.36	With increased figure from Orissa mainly
4.3 Water logged area	8.53	8.53	Includes area sub. to surface flooding as RBA*
4.4 Alkali soils	3.58	3.58	3.88 lakh ha increase for U. P., Punjab, & Haryana
4.5 Saline soil	4.04	4.04	Some report incomplete—55 lakh ha is as per
4.6 Coastal sandy areas	1.47	1.47	Anon. 1984. As per NCA such area ranges from
4.7 Riverain lands and torrents	2.73	2.73	5 to 8 m ha and av. is 6.5 m ha
4.8 Desert	22.25	11.77	Figures from H. P., Assam & Sikkim not available
			According to Report of NCA, 32 m ha are subject to
			wind erosion including 23.49 m ha of desert in
			Rajasthan, Haryana, & Gujarat. Latest figure for
			Rajasthan is less
Sub-total of 4.0	50.94	40.46	
Grand total of 1.0 to 4.0	298.48	167.08	

* Rashtriya Barh Ayog

Table 1.2 *Categories of degraded land in India*

Degraded land category	(Area-m ha)
Rainfed non-paddy areas	77.88
Other cultivable land including permanent pastures and cultivable wastelands	21.32
Forest land including protected and unclassified forest	19.49
Area not available for cultivation	7.93
Special problems such as gullied, ravines, alkali and saline lands, etc.	40.46
Total	167.08

Table 1.3 *State wise distribution of estimated affected area by soil erosion under various land utilization classes (Das, 1985)*

Sl. No.	State/U.T.	(Area-m ha)						Remarks
		Total cultivable land	Forest lands	Permanent pastures and grazing grounds	Barren lands	Non-agril. uses	Total for the State	
1.	Andhra Pradesh	9.095	1.148	0.367	0.454	0.438	11.502	Total cultivable lands
2.	Assam	0.770	0.883	0.074	0.308	0.182	2.217	include rainfed non-
3.	Bihar	2.634	1.021	0.056	0.202	0.347	4.260	paddy current fallow,
4.	Gujarat	8.410	0.484	0.336	0.500	0.216	9.946	fallow other than
5.	Haryana	1.440	0.056	0.010	0.014	0.071	1.591	current fallow miscel-
6.	Himachal Pradesh	0.585	0.839	0.442	0.024	0.024	1.914	laneous, tree crops &
7.	Jammu & Kashmir	0.510	0.210	0.048	0.055	0.060	0.883	groves and cultivable
8.	Karnataka	9.314	0.764	0.526	0.169	0.216	10.989	wastelands. The
9.	Kerala	1.503	0.180	0.002	0.017	0.055	1.757	problem area of the
10.	Madhya Pradesh	14.145	4.100	0.451	0.469	0.445	19.610	above lands has
11.	Maharashtra	16.412	1.592	0.633	0.346	0.198	19.181	been estimated to
12.	Manipur	0.005	0.080	—	0.284	0.005	0.374	be 25, 50, 20 and
13.	Meghalaya	0.479	0.289	0.007	0.046	0.017	0.838	50% of total
14.	Nagaland	0.271	0.128	—	—	0.006	0.405	area, respectively.
15.	Orissa	2.368	1.807	0.224	0.053	0.126	4.578	The problem area has
16.	Punjab	0.809	0.093	0.002	0.018	0.085	1.007	been estimated to
17.	Rajasthan	17.213	1.061	0.734	0.592	0.302	19.902	be 10% of reserved
18.	Sikkim	0.166	0.045	0.041	0.041	0.010	0.303	forests, 40%
19.	Tamil Nadu	2.707	0.398	0.066	0.116	0.353	3.640	protected, 50% of
20.	Tripura	0.021	0.122	—	0.024	—	0.167	unclassified forests,
21.	Uttar Pradesh	5.093	1.212	0.119	0.222	0.464	7.110	20% of barren
22.	West Bengal	0.479	0.269	0.002	0.024	0.259	1.033	total lands, and
23.	Arunachal Pradesh	0.131	2.286	0.020	0.004	0.003	2.444	20% of total
24.	Mizoram	0.243	0.134	0.002	0.040	0.002	0.421	non-agricultural
25.	Andaman & Nicobar	0.032	0.225	0.002	—	—	0.259	use lands.
26.	Chandigarh	—	—	—	—	0.001	0.001	
27.	Delhi	0.062	0.001	—	0.004	0.007	0.074	
28.	Goa, Daman, Diu	0.128	0.065	—	0.003	0.004	0.200	
29.	Pondicherry	0.001	—	—	—	0.002	0.003	
30.	Dadra, Nagar Haveli	0.010	0.002	—	—	—	0.012	
Total		95.030	19.494	4.164	4.029	3.898	126.620	

Till 1987–88 both under state (29.34 m ha) and central (2.74 m ha) sectors, about 32.08 m ha of agricultural and non-agricultural lands have been treated, by various soil conservation measures and under special programmes at an expenditure of about Rs.1739 crores. (Table 1.5)

Table 1.4 *State wise distribution of estimated area under special problems of degradation (Das, 1985)*

Sl. No.	States/U.T.	(Area-m ha)								Total for States
		Gully and Ravine	Shifting cultivation	Water logged		Alkali soils	Saline including coastal saline sandy area	Riverain lands Diara/ Khader Chaur	Desert Torrents/ Chos, Khad	
				NCA	RBA by surface flooding					
1.	Andhra Pradesh	—	0.150	0.339	—	0.064	0.176	—	—	0.729
2.	Assam	0.193*	0.139	—	0.450	—	—	NA	—	0.792
3.	Bihar	0.600	0.081	0.117	0.590	0.004	—	0.900	—	2.292
4.	Gujarat	0.400	—	0.484	—	0.942 ⁺⁺	0.100	0.010	—	0.704
5.	Haryana	**	—	0.620	—	0.450	0.076	0.025	NA	1.400
6.	Himachal Pradesh	*	—	—	—	—	—	NA	NA	—
7.	Jammu & Kashmir	—	—	0.010	—	—	—	—	—	0.010
8.	Karnataka	—	—	0.010	—	0.076	0.328	—	—	0.414
9.	Kerala	—	—	0.061	—	—	0.117	—	—	0.178
10.	Madhya Pradesh	0.683	0.125	0.057	—	0.164	0.078	—	—	1.107
11.	Maharashtra	0.020	NA	0.111	—	0.059	0.475	—	—	0.665
12.	Manipur	—	0.360	—	—	—	—	—	—	0.360
13.	Meghalaya	—	0.265	—	—	—	—	—	—	0.265
14.	Nagaland	—	0.077	—	—	—	—	—	—	0.077
15.	Orissa	0.113	2.648	0.060	—	—	0.404	—	—	3.225
16.	Punjab	0.120 ^{**}	—	1.090	—	0.718	— [@]	0.045	0.250	2.223
17.	Rajasthan	0.452	—	0.348	—	++	1.000	—	—	9.692
18.	Sikkim	—	—	—	—	—	—	—	NA	—
19.	Tamil Nadu	0.060	NA	0.018	—	0.004	0.100	—	—	0.182
20.	Tripura	—	0.112	—	—	—	—	—	—	0.112
21.	Uttar Pradesh	1.230	—	0.810	1.170	1.100	0.195	1.500	NA	6.005
22.	West Bengal	0.104	—	1.850	0.330	—	0.986	NA	NA	3.270
23.	Arunachal Pradesh	—	0.210	—	—	—	—	—	—	0.210
24.	Mizoram	—	0.189	—	—	—	—	—	—	0.189
25.	Delhi	—	—	0.001	—	—	—	—	—	0.001
Total		3.975	4.356	5.986	2.540	3.581	5.500 (4.035 +1.465)	2.480	0.250	11.796
										40.464

* Combined figure for Himalayan foot hills in Assam and Himachal Pradesh

** Figure for united Punjab including Haryana

++ Includes the areas of arid Rajasthan and Gujarat

@ Includes saline areas of arid Rajasthan and Runn of Kutch

1.3 Programme

With a view to checking soil erosion, soil and moisture conservation programmes were launched both under state as well as central sectors during the Five Year Plans.

COMPONENTS OF SOIL AND WATER CONSERVATION

The main components of soil and water conservation on different types of lands and various programmes have been as under:

(a) *Agricultural lands*: Bunding, terracing, land sloping, levelling, contour

Table 1.5 *State wise total problem areas, areas treated and balance yet to be treated (Das, 1985)*

Sl. No.	States/U.T.	(Area-m ha)		Total problem area	Area treated till 1987-88	Balance to be treated
		Due to soil erosion	Land degradation			
1.	Andhra Pradesh	11.502	0.729	12.231	0.927	11.304
2.	Assam	2.217	0.782	2.999	0.191	2.808
3.	Bihar	4.260	2.292	6.552	1.285	5.267
4.	Gujarat	9.946	2.640	12.586	2.381	10.205
5.	Haryana	1.591	2.571	4.162	0.497	3.665
6.	Himachal Pradesh	1.914	—	1.914	0.276	1.638
7.	Jammu & Kashmir	0.883	0.010	0.893	0.222	0.671
8.	Karnataka	10.989	0.414	11.403	3.260	8.143
9.	Kerala	1.757	0.178	1.935	0.434	1.501
10.	Madhya Pradesh	19.610	1.107	20.717	4.102	16.615
11.	Maharashtra	19.181	0.665	19.846	10.125	9.721
12.	Manipur	0.374	0.360	0.734	0.099	0.635
13.	Meghalaya	0.837	0.265	1.102	0.102	1.000
14.	Nagaland	0.405	0.077	0.482	0.088	0.394
15.	Orissa	4.578	3.225	7.803	0.724	7.079
16.	Punjab	1.007	2.223	3.230	0.630	2.600
17.	Rajasthan	19.902	11.492	31.394	1.628	29.766
18.	Sikkim	0.303	—	0.303	0.109	0.194
19.	Tamil Nadu	3.640	0.182	3.822	1.244	2.578
20.	Tripura	0.167	0.112	0.279	0.122	0.157
21.	Uttar Pradesh	7.110	6.005	13.115	3.148	9.967
22.	West Bengal	1.033	3.270	4.303	0.344	3.959
23.	Arunachal Pradesh	2.444	0.210	2.654	0.008	2.646
24.	Goa	0.200	—	0.200	0.027	0.173
25.	Mizoram	0.421	0.189	0.610	0.005	0.605
Union Territories						
26.	A & N Islands	0.259	—	0.259		
27.	Chandigarh	0.001	—	0.001		
28.	Dadra, Nagar Haveli	0.012	—	0.012	0.096**	0.254**
29.	Delhi	0.074	0.001	0.075		
30.	Daman, Diu	—	—	—		
31.	Lakshadweep	—	—	—		
32.	Pondicherry	0.003	—	0.003		
		126.620	38.999	165.619	32.074	133.545
			1.465*	1.465*		1.465
			40.464	167.084		135.010

* Coastal sandy not reported statewide.

** Total for Sl No. 26 to 32

cultivation and planting, water escapes and outlets for removal of excess water, follow up with improved crop technology (to be carried out through extension services).

(b) *Non-agricultural lands*: Closures, afforestation, raising of utility trees, plantations, grasslands development, contour trenching, stone walls, etc.

(c) *Engineering measures*: Engineering measures like water harvesting and silt de-

tention structures, treating gullies, stream banks, landslides and slips, mine spoils, etc., in both agricultural and non-agricultural lands.

(d) *Reclamation/restoration of degraded lands*: Particularly alkali soils, ravines, shifting cultivation areas, coastal saline lands, sand dune stabilization, etc.

SOIL AND WATER CONSERVATION PROGRAMMES

The following soil and water conservation programmes are being carried out by the central as well as the state governments under central/centrally sponsored foreign aided programmes during the Seventh Five Year Plan.

(a) *Soil conservation in catchment of river valley project (RVP)*

Year of start: Third Five Year Plan.

Objective: Treating the catchment areas for reducing silt production rate and subsequent siltation of the costly reservoir, thereby increasing their useful life. The scheme also helps to improve the productivity of the catchments by checking land erosion.

(b) *Integrated Watershed Management in the Catchments of Flood Prone Rivers (FPR)*.

Year of start: Fourth Five Year Plan.

Objective: Mitigate flood hazards, improve productivity of catchment area.

Area of operation: Catchments of eight flood prone rivers in the Gangetic Basin namely Ajoy, Gomti, Punpun, Roopnarain, Sahibi, Sone, Upper Ganga and Upper Yamuna. The total area of these eight catchments is 16.7 m ha and covers parts of the states of Bihar, Haryana, Himachal Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh, West Bengal and the union territory of Delhi.

Programme: Integrated watershed management in priority watersheds covering all types of land.

Achievement: The area treated up to 1987–88 is 0.28 m ha, out of an estimated 7 m ha of priority area (4%), with an expenditure of nearly Rs. 66 crores.

(c) *Drought Prone Area Programme (DPAP)*

Year of start: 1970–71

Objective: Integrated area development programme for restoration of ecological balance and optimum utilization of land, water, livestock and human resources, to mitigate the effects of drought.

Area of operation: The scheme operates in 615 blocks of 91 districts in 13 states. The total area covered by the programme is about 53.6 m ha (19% of geographical area of the concerned states). The population covered is 70.75 m.

Programme: Soil and moisture conservation including proper land use practices, water harvesting, afforestation, development of pastures and fodder resources are the major activities.

Achievement: Up to 1987–88, an area of about 2.1 m ha has been treated with soil and moisture conservation, 1.2 m ha has been covered under forestry and pasture development and irrigation potential has been created for nearly 0.8 m ha. The total investment up to 1987–88 has been about Rs. 934 crores.

(d) Desert Development Programme (DDP)

Year of start: 1977–78

Objective: Mitigating the effect of drought in the desert areas, control desertification, restore ecological balance and raise the productivity of land, water, livestock and human resources.

Area of operation: 131 blocks of 21 districts in five states covering both hot and cold arid areas. The states covered are Rajasthan, Haryana, Gujarat (hot arid region), Jammu and Kashmir, Himachal Pradesh (cold arid region). The total area covered by the programme is about 36.2 m ha and the population covered is about 15 m.

Programme: Mostly sectoral programmes of different line departments. Afforestation, sand dune stabilisation, shelter belt plantation, grassland development, water resource development, soil and moisture conservation and development of livestock resources are the main activities.

Achievement: Up to 1987–88 the achievements are 1.37 lakh ha covered under forestry and pasture development, 0.67 lakh ha treated with soil and moisture conservation and irrigation potential created for nearly 0.22 lakh ha. The total expenditure is about Rs.197 crores.

(e) National Watershed Development Programme for Rainfed Agriculture (NWDPA)

Year of start: 1986–87

Objective: To conserve and upgrade both crop lands and culturable wastelands on watershed basis; to stabilize and increase crop yields from rainfed farming; to augment the fruit, fodder and fuel resources through appropriate alternate landuse systems; to develop and disseminate technologies for proper soil and moisture conservation.

Area of operation: The programme is being implemented in the unirrigated arable lands mostly falling in the rainfall range 500–1125 mm and also above. The programme covers 99 districts in 16 states. The districts having more than 30% area under irrigation are generally excluded.

Programme: The main components of the programme are as follows:

- (i) Land and moisture management including scientifically tuned cropping system, dryland horticulture, fodder production and farm forestry.
- (ii) Contingency seed and planting material stocking.
- (iii) Training, seminars, study tours for staff and farmers within the state/ regional/ national level.
- (iv) Adoptive research trials on different crops in small and marginal farmers fields.
- (v) Procurement, fabrication and supply of survey equipment and prototype implements.
- (vi) Preparation of field manuals publicity materials.

The pattern of expenditure per ha is Rs.1000 on land and water development, Rs.1000 on crop production technology and Rs. 500 for staff, contingencies, etc.

Achievement: Up to 1987–88, 1.13 lakh ha has been covered with a total expenditure of Rs.13.38 crores.

(f) *Soil, Water and Tree Conservation in the Himalayas (Operation Soil Watch)*

Year of start: 1980–81

Objectives: To provide stability to the fragile and vulnerable Himalayan eco-system through engineering as well as vegetative methods of soil and water conservation. The scheme aims at giving integrated production treatments to selected catchments/watersheds mostly within the reserved and other forest lands.

Area of operation: The programme is continuing in the Himalayan ranges covering parts of 14 states, viz. Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Uttar Pradesh, West Bengal, Sikkim, Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Mizoram and Tripura.

Programme: The main components are afforestation, pasture development, stabilization of slips, gullies, torrents and terracing of critically eroding agricultural lands.

Achievement: Up to 1987–88 a total of about 2.3 lakh ha have been covered with a total expenditure of about Rs. 61.7 crores.

(g) *Operational Research Projects on Integrated Watershed Management (ICAR)*

Year of start: 1983–84

Objectives: To develop a programme with peoples' participation for arresting the deterioration of our environment and building up permanent assets in the form of water, sustainable vegetation and improved productivity of our cropped land.

Area of operation: As many as 47 watersheds (17 with CSWCRTI, Dehradun and 30 with CRIDA, Hyderabad) spread over 16 states, viz. Andhra Pradesh (4), Bihar (2), Gujarat (3), Haryana (6), Madhya Pradesh (5), Maharashtra (5), Orissa (2), Punjab (1), Himachal Pradesh (1), Jammu and Kashmir (1), Karnataka (5), Kerala (1), Rajasthan (3), Tamil Nadu (2), Uttar Pradesh (9) and West Bengal (2), covering a total area of 35,739 na.

Programme: Integrated management of natural resources, viz. soil, water, plant, man and animal for optimizing production of food, fodder, fuel, fibre, etc., on watershed basis was implemented by the state government, in which ORP is located, on the basis of the master plans prepared for the watersheds by CSWCRTI, Dehradun and CRIDA, Hyderabad. Funds for the programme was provided by the Ministry of Agriculture and Rural Development, Government of India and under the technical guidance of the ICAR.

Achievement: In most of the model watersheds, small-scale water resource system surface as well as underground have been created. Significant increases in water storage and recycling of the stored water were accomplished in most of the watershed, resulting in increased crop yields. *In situ* moisture conservation practices, such as contour cultivation, mulching, flat-on-grade and ridging systems, preformed bed-furrow system, off-season tillage, etc., have been implemented in the farmers field in the watershed. Even in the year of a severe drought in the country in 1987, the efforts of watershed management have minimized the severity of hardships in the watershed (Dhruva Narayana *et al.*, 1987).

(h) *Reclamation of Alkali Soils (Usar) in the State of Haryana, Punjab and Uttar Pradesh*

Year of start: The new programme was initiated in Punjab during 1985–86 and in Haryana and Uttar Pradesh during 1986–87.

Objectives: Reclamation of alkali soils and saline soils.

Area of operation: To cover large areas of alkali soils and saline soils in an area of about 7 m ha (alkalinity 4.5 m ha and salinity 2.5 m ha) covering the state of Punjab, Haryana and Uttar Pradesh.

Programme: Treating alkali soils with gypsum.

Achievement: A total of about 3.75 lakh ha have been reclaimed in the state of Punjab, Haryana and Uttar Pradesh.

(i) Ravine Reclamation in the Dacoit Prone Areas of Uttar Pradesh, Madhya Pradesh and Rajasthan to accelerate their Development

Year of start: 1980

Objectives: To check further spread of ravines into the adjoining productive table lands, improve the production of crops, fodder, fuel and other biomass, thereby improving the socio-economic conditions of the local people.

Area of operation: The scheme is in operation in 28 districts in the states of Uttar Pradesh (12), Madhya Pradesh (11), and Rajasthan (5).

Programme: The main components of the programme are peripheral bunding to check the spread of ravines, land development within 200 m along the peripheral bunds, afforestation of medium and deep ravines through manual planting and aerial seeding and reclamation of shallow ravines for cultivation with provision of irrigation.

Achievement: Till the end of the Seventh Plan, it is expected that an area of about 46,000 ha will be treated with an investment of Rs. 42.1 crores.

(j) Control of Shifting Cultivation

Year of start: 1986–87

Objectives: Restoring ecological balance in hilly areas and improving socio-economic conditions.

Area of operation: The programme is in operation in nine states (seven states of North Eastern Region, Andhra Pradesh and Orissa).

Programme: Settling nearly 25,000 Jhumia families on agricultural and plantation lands.

Achievement: About 2500 families have been settled over 5000 ha at a cost of about Rs. 2.17 crores.

(k) World Bank Himalayan Watershed Project (Uttar Pradesh)

Year of start: Seven years from 1983.

Objectives: Minimise deterioration of ecosystem. Improve productivity of all land uses.

Area of operation: Two watersheds in Garhwal and Kumaon regions of Uttar Pradesh covering 3.12 lakh ha.

Programme: Integrated watershed development.

(l) World Bank Project on Watershed Development in Rainfed Area

Period of operation: Seven years from 1984.

Objectives: Develop technology for increasing crop and forage, fuelwood and timber yields in selected rainfed areas.

Area of operation: As much as 25,000 ha each in the states of Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra.

Programme: Integrated development.

(m) *World Bank aided Kandi Development Project*

Period of operation: The Sixth and Seventh Plans

Objectives: Development of land, water and forest resource of Kandi area.

Area of operation: Kandi area in Punjab

Programme: Integrated development

(n) *Indo-EEC Watershed Management Project (Gujarat)*

Period of operation: Two and a half years from 1986.

Objectives: To increase agricultural production, fodder, fuel and help small and marginal farmers in tribal areas.

Area of operation: As many as 89 watersheds in 14 districts to cover about 50,900 ha in Gujarat state.

Programme: Integrated development

(o) *Indo-EEC integrated Watershed Management in Ravinous areas of Chambal and Uttar Pradesh*

Period of operation: Six years from 1987.

Objectives: To improve production of ravinous areas for agriculture, forests, to control ravines extension, to improve economic condition.

Area of operation: Parts of Agra and Etawah districts of Uttar Pradesh, covering 57,000 ha.

Programme: Integrated development

During the Eighth Five Year Plan (1990–91 to 1994–95), a total area of 14.565 m ha is likely to be treated, consisting of 11.425 m ha of agricultural land and 3.14 m ha of non-agricultural lands at a total cost of Rs.4,203.50 crores as compared to the Seventh Plan target of 7.5 m ha at an outlay of Rs.826.27 crores.

During the Eighth Plan, additional biomass production is estimated to be of the order of

(i) 5 m tonnes of food grains, pulses, oilseeds;

(ii) 15 million cu m of biomass/annum from non-arable lands.

A total of 840 million man days of employment is expected to be generated with the above soil conservation plan.

The strategy for agricultural development during the Eighth Five Year Plan (FYP) is to achieve the national objectives of self-reliance, food security, generation of employment and improvement of the socio-economic condition of the small farmers. Realising the importance of land and water as life supporting resources, the important components of strategy should cover massive land development, reclamation of degraded lands and development of optional land use for different farming systems and other land uses as per the nature, capabilities, problems and potentials of the land and water resources in different physiographic-cum-agroclimatic regions and sub-regions of the country.

Soil and water conservation meaning proper land and water management on sustained basis, improving the productivity of these resources and stemming the deterioration assumes an important place in implementing the Eighth FYP strategy, so as to lead to sustained development and upward looking stable economy and it is more so, in the face of ever rising human animal population and increasing diversified competing demands on land and water.

1.4 National Land Resource Regions

Classification of land into land resource regions and areas is useful for determining the national soil and water conservation needs, for organising research and also for correlating the technical guides between the political divisions (states). This classification also helps in utilizing the research experience of one place to other places of similar soil climatic and topographic conditions. The CSWCRTI, Dehradun, therefore, prepared a land resource region and areas map of India, based on the available information on soil, forest areas, forest types, rainfall, land use and elevation of India (Gupta *et al.*, 1970).

The country has been divided into 20 land resource regions (A, B, C, ..., T) based on vegetation, soil and rainfall. All the islands of the country have been grouped into one region (Table 1.6). Region N (black soil region) has the largest area (67 m ha) followed by O region (eastern red soil region—57 m ha).

Table 1.6 Areas of land resource regions

Area	Land (Area-m ha)
A) Northern Himalayas snow clad region	11.600
B) Northern Himalayas alpine grass and meadow region	9.825
C) Northern Himalayas forest region	13.175
D) Punjab-Haryana alluvial plain region	10.125
E) Upper Gangetic alluvial plain region	20.000
F) Lower Gangetic alluvial plain region	14.550
G) North-Eastern Himalaya alpine grass and meadow region	1.600
H) North Eastern forest region	16.100
I) Arunachal valley region	8.850
J) Rajasthan desert region	19.100
K) Runn of Kutch region	4.650
L) Gujarat alluvial plain region	6.275
M) Mixed yellow, red and black soil region	11.575
N) Black soil region	67.350
O) Eastern red soil region	57.350
P) Gangetic delta region	2.525
Q) Western coastal region	6.100
R) Southern red soil region	34.775
S) Eastern coastal region	9.350
T) Andaman, Nicobar and other islands	0.800
Total for the country	325.675

Twenty land resource regions have been sub-divided into 186 land resource areas (1, 2, 3, ..., 186), mostly based on the land use, e.g. forest, irrigated or unirrigated land. Unirrigated agricultural lands have been sub-divided into

different land resource areas, depending upon rainfall and soil type. The rainfall zones of 0 to 10, 10 to 40, 40 to 80, 80 to 200 and 200 to 400 cm have been used and named as arid, semi-arid, sub-humid, humid, and per-humid, respectively.

Land resource area No. 137 in land resource region O (Eastern red soil region) is maximum (21 m ha). With this broad grouping of land resource region and areas, it is essential that land resource unit maps are prepared on large scale on state maps, using the detailed data available with the states. This will help to take into account the many details of local significance, which had to be omitted in the preparation of the National Land Resource Regions and Areas Map.

Recently (Das, 1977) the above land resource regions have been regrouped into ten soil conservation regions. The extent of area, rainfall and major problems are briefly discussed in Table 1.7.

Planning Commission (Khanna, 1989) has initiated Planning process of the Eighth Five Year Plan for the 15 agro-climatic regions, based on the criteria of homogeneity in agro-characteristics such as rainfall, temperature, soil, topography, cropping and farming systems and water resources.

AGRO-CLIMATIC REGION (ACR)

(a) *Western Himalayan Region*

Area of operation: Sub-zones of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh Hills.

Characteristics: Skeletal soils of cold region of podsollic soils, mountain meadow soils and hilly brown soils, steep slopy lands, silt loam soils, prone erosion hazards and landslides and slips are quite common.

<i>Thrust area</i>	<i>Strategy</i>
Water conservation and use	Integrated watershed development programme including forestry, horticulture, commercial crops and fodder for animals
Land use planning	Using land as per its capability. Up to 30% slopes—suitable for agriculture on terraces. 30–50% slope—Horticulture and silvi-pastoral programme. Above 50% slope—Forestry
Crop diversification	High value and low value crops, such as pomology, olericulture, floriculture, medicinal and aromatic plants and tea
Post harvest technology	Storage and cold storage, transport, marketing and processing
Irrigation management	Water harvesting techniques, water saving devices such as drip, mist formation and sprinkler

Table 1.7 *Statement showing distribution of different soil conservation problems in various soil conservation regions of India*

Sl. No.	Soil conservation region	Area (m ha)	Rainfall (mm)	Important areas	Problems
1	2	3	4	5	6
1.	North Himalayan (excluding cold desert areas)	25.53	500–2500	Snow clad mountains, temperate, arid, semi-arid and sub-humid areas of J & K, hill areas and H. P. (Kundi areas)	Soil erosion along hill slopes, landslides, torrent management of ravine lands siltation of reservoirs, over grazing and deforestation
2.	North-Eastern Himalayas	17.70	1500–2500	North-eastern hills of Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Assam, Nagaland, Tripura and West Bengal	Shifting cultivation, landslides, torrents and gullies, problem of riverine lands, siltation of reservoirs and stream beds
3.	Indo-Gangetic Alluvium soils	50.90	700–1000	Punjab, Haryana, North-Eastern Rajasthan, U. P., and Bihar plains, Chambal command in Rajasthan, command areas in Gujarat	Sheet erosion, ravines, floods, stream bank erosion, ravine lands, saline alkaline lands, water logging and riverine lands, prolonged dry spells and failure of rains, shortage of fuel and fodder
4.	Assam Valley and Gangetic delta	11.18	1500–2500	Plains of Assam, Tripura, North Bengal and Gangetic deltas, areas of West Bengal	Gully erosion, stream bank erosion, waterlogging, coastal salinity
5.	Desertic area	23.85	150–500	Western-Central Rajasthan, contiguous areas of Haryana and Gujarat, Runn of Kutch	Shifting sand dunes, wind erosion, extreme moisture stress and drought, overgrazing, improper land management
6.	Mixed Red, black and yellow soils	11.57	600–700	Districts of Pali, Bhilwara, Ajmer, Chittorgarh, Udaipur, Jhalawar and Southern U. P. (including Bundelkhand area) and Northern M. P.	Ravine, shortage of moisture, recurring drought, problem of drainage, overgrazing, improper crop technology, siltation of reservoirs and tanks
7.	Black soils (excluding shallow, medium and deep black soils)	67.45	Outer part 600–750–1000 inner 500–600	South-Eastern Rajasthan, part of Western Madhya Pradesh, large tracts of Maharashtra, Andhra Pradesh, Karnataka and small parts of Tamil Nadu	Sheet erosion, acute water shortage, recurring droughts, ill-drained soils and improper technology for agriculture and fodder, i.e., siltation of reservoirs, ground water recharge
8.	Eastern Red soils	57.45	1000–1500	Bulk of West Bengal, Bihar, Orissa and Eastern Madhya Pradesh including Chotanagpur and Chattisgarh area, part of Andhra Pradesh	Problem of sheet erosion, gullies, acute water shortage, recurring drought, heavy grazing and improper technology for crop husbandry and land management, siltation of reservoir and tanks

Table 1.7 (Contd.)

1	2	3	4	5	6
9.	Southern red soils	34.77	Around 750 in Kerala up to 2500	Bulk of Kerala, Tamil Nadu hills and plains, Karnataka, Andhra Pradesh and part of Maharashtra	Problem of sheet erosion, gullies acute water shortage, recurring drought, lack of fodder and fuel, improper crop husbandry, siltation of reservoir and tanks, ground water recharge
10.	East-West coasts	19.20	East-Coast about 1000 and rest heavy rain-fall	East and West Coast from Orissa to Saurashtra	Problem of coastal salinity, soil erosion, coastal sand dunes, wind erosion and flooding of cultivated lands by sea water or rain water.

Livestock management Integrated approach to breeding, feeding and adequate health cover

Public finance Credit support strengthening and simplified procedure

(b) *Eastern Himalayan Region*

Area of operation: Sikkim and Darjeeling Hills, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Tripura, Mizoram, Assam and Jalpaiguri and Cooch Behar districts of West Bengal.

Characteristics: High rainfall—high forest cover-shifting cultivation (*Jhum*), practised in nearly one-third of the cultivated area, has caused denudation and degradation of soils with the resultant heavy runoff, massive soil erosion and floods in the lower reaches and basins.

Thrust area

Strategy

Soil and water conservation Integrated watershed development programme

Improvement of farming system Legislation and people's awareness about the ill effects of shifting cultivation

Integrated farming system

(c) *Lower Gangetic Plains*

Area of operation: The West Bengal-Lower Gangetic plains region consisting of four sub-regions, namely Basins plains, central alluvial plains, alluvial coastal plains and tarh plains.

Characteristics: Frequent floods destroy standing crops in Basins and Central Plains:—Poor water management and drainage systems—Inadequate water harvesting techniques—Lack of well knit marine fisheries programmes

Thrust area

Strategy

Minor irrigation development Supplemental irrigation, increase ground water exploitation

Crop productivity improvement	Increase productivity in crops
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Livestock, poultry and fisheries development	Integrated approach to breeding, feeding and adequate health cover, as well as development of marine fisheries.
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(d) *Middle Gangetic Plains*

Area of operation: As many as 12 districts of eastern Uttar Pradesh and 27 districts of Bihar plains.

Characteristics: An area of 16 m ha with a high population of 85 m; high rainfall with a cropping intensity of 142%. In Bihar plains, flood prone areas amount to about 1.7 m ha and problem area of diara lands account for 1.0 m ha.

<i>Thrust area</i>	<i>Strategy</i>
Crop productivity improvement	Increase rice productivity
Poultry, dairy and inland fisheries	Integrated approach to breeding, feeding and adequate health cover.

(e) *Upper Gangetic Plains*

Area of operation: As many as 32 districts of Uttar Pradesh (sub-zones of central, north-west and south-west)

Characteristics: This area has 131% irrigation intensity, 144% cropping intensity with 9 lakh ha problem soils.

<i>Thrust area</i>	<i>Strategy</i>
Crop productivity improvement	Increase rice productivity
Crop diversification	Increase area under fruits and vegetables
Processing and marketing	Agro-based industries
Dairy improvement	Breeding, feeding and adequate health cover.

(f) *Trans-Gangetic Plains*

Area of operation: Punjab, Haryana, union territory of Delhi and Chandigarh and Sriganga district of Rajasthan.

Characteristics: Highest net sown area, irrigated area, least poverty level, high cropping intensity, high ground water utilization.

<i>Thrust area</i>	<i>Strategy</i>
Water management soil correction	Maximise production per unit of land and water reclamation of salt affected lands
Crop diversification	Introduction of pulses, increased area under fodder, fruits and vegetables
Livestock management	Integrated breeding, feeding and management
Processing and marketing	Agro-based industries

(g) *Eastern Plateau and Hills*

Area of operation: (i) Sub-region of Wainganga, Madhya Pradesh eastern hills and Orissa inland; (ii) Orissa northern and Madhya Pradesh eastern hills and plateau; (iii) Chotanagpur north and eastern hills and plateau; (iv) Chotanagpur south and West Bengal hills and plateau; and (v) Chattisgarh and south-western Orissa hills.

Characteristics: Rainfall is high and soils are shallow and medium in depth. Topography is undulating with a slope of 1 to 10%. Tank irrigation and tubewell irrigation are adopted.

<i>Thrust area</i>	<i>Strategy</i>
Water conservation and use	Integrated watershed development programme, rain water harvesting and management
Minor irrigation development	Supplementary irrigation and increased ground water exploitation
Crop productivity improvement	Increase rice productivity
Horticulture development	Marketing and processing facilities
Soil correction	Reclamation of acidic soils by application of lime
Animal husbandry, fisheries, poultry duck farming development	Breeding, feeding and development
Rehabilitation of degraded land	Rehabilitation of peripheral forests on a large scale

(h) *Central Plateau and Hills*

Area of operation: As many as 46 districts of Madhya Pradesh, Uttar Pradesh and Rajasthan.

Characteristics: Ravine and hill topography. One-third of the land is not available for cultivation. Irrigation and intensity of cropping are low. The literacy percentage is low and the poverty percentage is high; 75% of the area is rainfed.

<i>Thrust area</i>	<i>Strategy</i>
Soil and water conservation	Integrated watershed development programme
Crop productivity improvement	Low value cereal crops to be substituted by high value ones
Minor irrigation development	Increase ground water exploitation
Crop diversification	Increase area under fruits and vegetable crops
Ravine area development	Reclamation of ravine land
Improvement of cattle productivity	Breeding and supply of better quality fodder

(i) *Western Plateau and Hills*

Area of operation: Major part of Maharashtra, parts of Madhya Pradesh and one district of Rajasthan.

Characteristics: Annual average rainfall is 904 mm. Net sown area is around 65%, forests occupy 11%, irrigated area by canal system is 12.4%. *jowar* and cotton are the major crops of the area—50% of the country's *jowar* production and one-fifth of the country's cotton production is from this region. This zone is well known for oranges, grapes and bananas. The area under fruit crop is 0.1 m ha.

<i>Thrust area</i>	<i>Strategy</i>
Minor irrigation development	Supplemental irrigation and increase ground water exploitation
Soil and water conservation	Integrated watershed development programme, rain water harvesting and management
Improvement of cattle productivity	Breeding and feeding

(j) *Southern Plateau and Hills*

Area of operation: As many as 35 districts of semi-arid zone of Andhra Pradesh, Karnataka and Tamil Nadu.

Characteristics: Rainfed farming comprises 81% of the area, cropping intensity is 111%, low value cereals and minor millets predominate in the cropping system.

<i>Thrust area</i>	<i>Strategy</i>
Minor irrigation development	Increase ground water exploitation
Crop diversification	Increase area under crops requiring low moisture
Horticulture development	Develop each year 0.5 m ha under mango, <i>ber</i> , pomegranate, citrus and guava
Improvement of cattle productivity	Breeding and feeding

(k) *East Coast Plains and Hills*

Area of operation: Orissa coastal, north coastal Andhra Pradesh and Ganjam, south coastal Andhra, north coastal Tamil Nadu, Thanjavur and south coastal Tamil Nadu.

Characteristics: This zone accounts for 20% of all India production of rice and 17% of the total groundnut output. Alkaline and saline lands are found in the coastal areas and covers 4.9 lakh ha. Waterlogging is quite common.

<i>Thrust area</i>	<i>Strategy</i>
Fisheries	Development of fisheries
Soil and water conservation	Integrated watershed development programme
Water management	Maximise production per unit of land and water
Management of paddy lands	Integrated irrigation-cum-drainage system

Fisheries	Improvement of marine and brackish water fisheries and aquaculture
Improvement of farming system	Shifting cultivation to be replaced by an integrated horticulture-agricultural programme
Improvement of cattle productivity	Breeding and feeding

(l) *West Coast Plains and Ghats*

Area of operation: West coast covering parts of Tamil Nadu, Kerala, Karnataka, Maharashtra and Goa.

Characteristics: Important zone for plantation crop and spices. Literacy is the highest in Kerala and so is unemployment.

<i>Thrust area</i>	<i>Strategy</i>
Rain water management	Conserve rain water
Minor irrigation development	Increase ground water exploitation
Crop diversification	Increase area under fruits and vegetables
Fisheries development	Strengthen marine and inland fisheries
Soil correction	Reclamation of <i>Pokhali</i> lands

(m) *Gujarat Plains and Hills*

Area of operation: As many as 19 districts of Gujarat classified into seven sub-zones.

Characteristics: The zone is arid with low rainfall in most parts and only 22.5% of the area irrigated through wells and tubewells. As much as 50% of the cultivated area is occupied by food crops, rendering it a deficit zone. It is an important oilseed zone. Cropping intensity is 114%. About 60% of the area is considered drought prone and 78% of farming is rainfed.

<i>Thrust area</i>	<i>Strategy</i>
Water conservation and use	Integrated watershed development programme, rain water harvesting and management, development of water grid
Dryland farming	Evolve suitable technology for dryland farming
Water management	Maximise production per unit of land and water, check overdrawal of groundwater
Wasteland development	Develop agroforestry and arid horticulture

(n) *Western Dry Region*

Area of operation: As many as 9 districts of Rajasthan

Characteristics: This area is characterized by hot sandy desert, erratic rainfall, high evaporation, no perennial river and scanty vegetation. Ground water is deep and often brackish. Famine and drought are common features. Land-man ratio is high (1.73 ha/person). Average annual rainfall is only 395 mm, forest area is only

1.2%, land under pasture is also low (4.3%). The net irrigated area is only 6.3% of net sown area (44.4%), cropping intensity is just 105%. *Bajra*, *guar* and *moth* are the lead crops in *Kharif* and wheat and gram in *Rabi*—density of livestock is 1.08 animal/ha and 1.56 animal per person.

<i>Thrust area</i>	<i>Strategy</i>
Desert land development	Develop silvipastoral and energy plantation, sand dune stabilization
Water conservation and use	Integrated watershed development programme, <i>in situ</i> moisture conservation on practices

(o) *Island Region*

Area of operation: It comprises island territories of the Andaman and Nicobar Islands and Lakshadweep.

Characteristics: Rainfall is 3000 mm, spread over 8 to 9 months. Largely it is a forest zone with undulating areas leading to heavy loss of soil due to runoff. Half the cropped area is under coconut. It has a high literacy rate and low poverty level.

<i>Thrust area</i>	<i>Strategy</i>
Crop improvement	Maximise production for unit of land
Water management	Integrated watershed development programme, rainwater harvesting and management
Fisheries	Development of fisheries