CHAPTER - VII

SURFACE WATER RESOURCE

INTRODUCTION

The district falls in the semiarid to arid climatic zone and its overall water resource potential of the district is poor (Rao,1979). It has been reflected in the general harsh conditions of the environment. The water resource regime of the district is governed by the natural factors like low and erratic rainfall, extreme topographic variation, complex hydrogeologic framework and the unscientific development and management practices.

An obvious inhomogenity of water resource availability is noted but there exists a good natural balance of internal transfers and distribution in space and time. This has helped to a considerable extent in sustaining the sensitively fragile environment. However, the inter-relationship of the water resource regime and the environmental conditions, has not attracted attention of earthscientist and therefore the field has remained unexplored. The conventional approach of exploitation and utilization of the water resource without understanding the same have adversely affected the natural ecological balance.

In this chapter, an attempt has been made to review the conditions of surface water resource its harnessable potential, availability, development strategy and management practices.

AVAILABILITY OF SURFACE WATER

The total availability of the surface water for the district is contributed by different internal and external sources. The dominant internal source of supply is the runoff produced from the precipitation falling within the geographical limits of the district. The external sources on the other hand include: (i) The runoff entering the district from the upper catchment of the neighboring Rajasthan State and (ii) a limited quantity of significant value allocated from the Narmada Project.

INTERNAL SOURCES

The available internal resource is determined by the surface runoff produced from the factors of rainfall, terrain characters and the climatic conditions, and it has been observed that the three different geoenvironmental units of the district are characterised by their own distinct sets of these factors. Accordingly the resource availabilities for the three units are also quite different.

RAINFALL PATTERN

The rainfall is obviously the most important factor that determines surface water availability of the district which shows a quite an erratic rainfall pattern. The district is influenced by arid regions located in its western and northern portions, the Ranns of Kachchh in the west, and the desert of Thar in the northeast While less arid alluvial plains of Mehsana and Ahmedabad districts on the southern flank and sub-humid rocky areas bordering to the east. All these diverse climatic characters are reflected in the rainfall pattern of the district.

The average rainfall for the Banaskantha district is 555 mm. The rainfall characteristics for the important observation stations as monitored by the India Meteriological Department and State Agriculture Department present a good regional scenario (Table 7.1)

Table 7.1 Regional Rainfalll characteristics of Banaskantha district.

Features	IMD (1931-1960) Obsn. stations			DOA (1961-1989) Obsn. stations			
	Bhuj	Deesa	Kachchh	Banaskantha	Mehsana	Ahmedabad	Sabarkantha
Average rainfall (mm)	349	575	344	597	570	680	715
Number of rainy days	15	27	14	27	25	32	32
Maximum (mm) (Year)	1177 (1926)	1038 (1959)	929.2 (1980)	1251 (1977)	1701 (1975)	1282 (1976)	1377 (1974)
Minimum (mm) (Year)	21.8 (1899)	291.3 (1951)	5.8 (1987)	55.8 (1987)	100.4 (1987)	251 (1987)	165 (1987)
Heaviest in 24 hrs (mm) (Year)	467.9 (1959)	53.2 (1960)	469.9 (1959)	409.7 (1893)	-	475 (1905)	463 (1941)

The data reveal that there is a steady increase of rainfall from west to east. The district is located within two extreme ends of average rainfall of 348 mm in the west (Bhuj) to 1691 mm (Mt.Abu) in east, but the range of variation is relatively short as traced from north to south. The average rainfall in the adjoining Jalor district in the north is 422 mm while in the southern districts of Mehsana and Ahmedabad it increases to 570 mm and 680 mm respectively. The Sabarkantha district to the east shows a higher average of 715 mm. The values for the rainy days, extremes (max.and min.) and the intensity (heaviest in 24 hrs) for the adjacent districts also show the similar patterns.

The three geoenvironmental units of the district marked by variations in their physiographic and climatic settings show difference in the rainfall pattern. The talukawise average rainfall values as compiled from the data of 70 years (1901 to 1970) by the State Department of Agriculture (Table 7.2) show this variation clearly. Along E-W direction the district shows variation from 421 mm to 906 mm.

Table 7.2 Rainfall variations within the district.

(Based on DOA data : 1901 to 1972).

Geoenvironmental units	Taluka	Rainfall chracteristics	
		Average rainfall (mm)	Rainy days (Number)
Eastern Rocky Highland (ERH)	Danta	906	40
	Vadgam	689	30
	Palanpur	758	32
	Dhanera	461	21
	Average	704	31
Central Alluvial Plain (CAP)	Deesa	593	27
	Kankrej	579	23
	Deodar	406	21
	Average	526	23
Western Saline Wasteland (WSW)	Santalpur	451	19
	Radhanpu	440	19
	r	432	21
	Vav	421	20
	Tharad		
		436	20
	Average		
District Average		540	23

The Water Resource Investigation Circle of the Irrigation Department maintains 41 Raingauge Stations (Fig 2.5) in the district as a part of its statewide rainfall monitoriang programme. To highlight the variable character of the rainfall for different geoenvironmental units, data for a sample year of 1992-93 were collected (Annexure 7.1) and analysed (Table 7.3).

Table 7.3 Geoenvrionmental unit wise rainfall characteristics .

Rainfall characters	ERH (24 Stns) Rainfall (mm)	Rainy days	CAP (7 Stns) Rainfall (mm)	Rainy days	WSW (9 Stns) Rainfall (mm)	Rainy days	District (41 Stns) Rainfall (mm)	Rainy days
Average for unit	904	35	825	33	643	31	791	33
Maximum (mm)	1461	46	1132	43	1069	42	1461	46
Minimum (mm)	557	25	422	23	245	17	245	17
Difference (2-3)	894	21	710	20	824	25	1216	29
Dev.from Av.								
Plus	+ 557	+11	+307	+10	+426	+11	+670	+16
	(62 %)	(31)	(37%)	(30%)	(66%)	(35%)	(84%)	(48%)
Minus	-337	-10	-403	-13	-358	-14	-546	-16
	-(37%)	-(29)	-(49%)	-(39%)	-(56%)	-(45%)	-(69%)	-(48%)

TERRAIN FACTORS

The various terrain factors control the rainfall receipt and convert it into runoff to form availability of surface water. So, the study of topography, drainage, ground slope, landforms, soil types, hydrogeological framework are very significant in the assessment of the problem of surface water availability. Details of these factors have been given in earlier chapters on geoenvrionmental units. Unitwise comparative summary (Table 7.4) of the relevant terrain parameters gives an idea of variability range of the runoff generation.

Table 7.4 Comparative summary of terrain parameters governing runoff.

Terrain Parameters	ERH	CAP	WSW
Landscape	Highly undualating	Plain	Plain
Elevation range	1000 to 200 m	200 to 50 m	50 to 20 m
Landform	Erosional	Depositional	Depositional
Relief difference	800 m	150 m	50m
Ground Slope Average: Variation:	 1:100 1:2 to 1:200	 1:400 1:50 to 1:1000	 1:800 1:50 to 1:1000
Drainage density	Very high (2-5 km / sq km)	Very low (0-1 km/ sq km)	Very low (0-1 km/ sq km)
Drainage frequencey	Very high (1 to 9 /sq km)	Very low (0-1 /sq km)	Very low (0-1/ sq km)
Soils	Shallow , coarse gravelly well drained, low AWC.	Very deep, loamy well drained moderate AWC	Very deep, fine loamy clayey, high AWC
Geohydrology	Exposed crystallines (consolidated)	Alluvium Aeo-fluvial (unconsolidated)	Alluvium Aeo-fluvio-marine (unconsolidated and semiconsolidated)
Runoff	High (121 mm)	Low (62 mm)	Low (62 mm)

It is observed that there is a marked variation in the runoff generation; relatively high in the ERH unit is just half of it in the adjoining units CAP and WSW.

RUNOFF

The rainfall characters and terrain factors which govern the surface runoff generation are most uneven in the district.

The State and Central Government agencies have a network river gauging to measure the runoff produced in their respective catchments. In the district there are 11 such stations (Fig. 2.5). Department of Water Reosurce Development (WRD, 1989) have also computed runoff for Major and Medium river valley projects at their reservoir sites. The gauge data give an quantitative idea of the surface water availability in space and time. The average river gauge discharge values (Table 7.5) as computed from last data of last 5 to 10 years for the 14 different gauging locations show on an average a runoff value of 83mm which is just 7.5% of the annual rainfall. Thus total quantity of available surface potential at average rainfall for the whole of the district works out as 1054 MCM. This is a poor potential relative to the other districts of the state.

Table : 7.5 River gauge runoff in Banaskatha (1980 to 1991).

River Basin	Gauge Station	Taluka	Catchment (sq km)	Runoff		
				Total Vol. (MCM)	Depth (mm)	% of Rainfall
ERH Unit						
Sabarmati	Dharoi	Kheralu	5475	1052.0	192	30.3
Banas	Roho	Palanpur	1230	144.8	118	13.3
Sipu	Bhkudar	Dhanera	1222	69.0	56	6.3
Balaram	Chitrasani	Palanpur	325	25.1	77	8.7
Sareswati	Navavas	Danta	63	6.2	98	11.0
Arjuni	Mota sada	Palanpur	265	39.0	150	23.0
Siri	Ganpipli	Danta	110	10.9	99	11.3
Saraswati	Mukteshwar	Vadgam	306	56.5	185	20.3
	Av.runoff for ERH				122	15.5
CAP Unit						
Rel	Runi	Dhanera	210	8.5	40	4.5
Banas	Deesa	Deesa	1720	81.8	48	8.5
Banas	Umaro	Kankrej	2436	72.6	30	5.8
Umardasi	Kanodar	Palanpur	219	10.0	50	7.0
Sareswati	Pilucha	Vadgam	764	9.5	12	1.9
Saraswati	Patan	Patan	1457	124.0	85	8.3
WSW Unit		-	-	-	-	-
	Av. runoff for CAP & WSW				44	8.0
	Av. runoff for the district				83	12.0

Average Annual surface water potential of the district is 1054 MCM (83 mm x 12700 km^2). The surface water potential for highland area is twice that of Central Alluvial Plain. There are no gauge stations in the Western Saline Wasteland. The rainfall and terrain characters are most adverse for runoff generation, as a result the same is almost one third of the ERH unit.

Recently, the TEC (1995) by using the available gauge discharge data and employing modern computation method of MRS (Monthly Runoff Simulation) for hydrological water balance model, worked out rainfall-runoff relationship for all the river basins of Gujarat including that for Banaskantha. Yearly surface water flow in the rivers of the district (Table 7.6) reveals that surface water progressively increases from west to east.

Table 7.6 Yearly surface water flow in subcatchment of Banaskantha.

Subcathment	Area within district(sq km)	Yearly flow by dependabiliy 75%		60%		50 %	
		MCM	mm	MCM	mm	MCM	mm
(A) ERH Unit							
Banas upto Dantiwada dam	958	62.9	65	83.0	87	115.5	121
Sipu upto sipu dam	254	16.5	65	22.1	87	30.7	121
(B) CAP Unit							
Free catchment below Dantiwada and sipu upto Khakhal	2,445	80.9	33	108.1	44	150.4	62
(C) WSW Unit							
Below Khakhal	726	23.7	33	31.6	44	44	62
Total River Basins (representative for the district)							
Banas	4,383	184	45	244.8	59	340.6	80
Rel	238	7.8	33	13.3	60	16.7	70
Saraswati	2,282	75.3	33	13.3	60	16.7	61
District average	-	-	37	-	54	-	70

The average runoff values for the ERH is relatively much higher (121 mm) but for the CAP and WSW units is much low (62 mm) just half of the ERH. The surface water potential, therefore for the three areas has been separately computed on the different runoff values (Table 7.7).

Table :7.7 Surface water potential for the three geoenvironmental units.

Unit	Area (sq km)	Potential at rainfall dependibilities					
		75%		60%		50%	
		mm	MCM	mm	MCM	mm	MCM
ERH	3800	65	247.0	87	330.6	121	459.8
CAP	5100	33	168.3	44	224.4	62	316.2
WSW	3800	33	125.3	44	167.2	62	231.8
Total District	12700	42	540.7	57	722.2	79	1007.8

Average surface water potential is generally considered at 50% rainfall dependability, and accordingly the district has been considered to have 1007.8 MCM potential. It is observed that ERH has rich potential as compared to the other two units. This unit (ERH) though covers 30% area of the district, shares almost 46% of the total surface water resource. In the other two units the surface water availability is relatively much low.

EXTERNAL RESOURCES

There are two different sources of external water for the district. The runoff received from upper catchment falling in the state of Rajasthan forms one source while the Narmada canal in western part forms other source.

UPPER CATCHMENT

The upper catchments, of the rivers of Banas, Sipu and Rel covering a total area of 3100 sq km lies in Rajasthan, outside the study area (Fig 1.3). The average runoff factor in the upper catchment is 121 mm and a substantial amount of 375 MCM of surface water flows into the district(TEC, 1995). Sabarmati river which forms the eastern border of the district has a total catchment of 5475 sq km with its average surface flow of 1052 MCM upto Dharoi dam. But due to the physiographic constraints this huge quantity is not available for use to the district. As a result Sabarmati water does not contribute to the total surface water resource of the district. On the contrary, three streams of the district viz.; Siri, Kidi and Dhamni with total catchment of about 300 sq km drains into Sabarmati depriving the district to use. Taking into account the runoff factor of 121 mm, about 36 MCM surface flow gets lost to Sabarmati. Thus considering this loss to Sabarmati and gain from adjoining state through Banas, Sipu and Rel (375 MCM), the net exogenous natural resource to the district is about 339 MCM. This amounts to almost 33% of the total internal resource of the district. Thus total surface water resource for the district could be computed as 1346 MCM Of this, the quantity available for development at 70% could be taken as 942 MCM

NARMADA CANAL

The other external source of water to the district which has been planned to be provided is from the Narmada Project. The Radhanpur-Vav area (Agro-climatic Region No. 12 of the Narmada Command) comprising 3197 sq km has been covered under the canal command (Fig 7.1). It is expected to receive annually a water supply of about 1328 MCM/Yr (NPG,1989). This quantity is more than the total water resource potential of the district. Adding this to the presently available usable resource (942 MCM), the total usable quantity for the district would be 2270 MCM. The additional water from Narmada, however is to be exclusively used in the Western Saline Wasteland (WSW) area of the district.

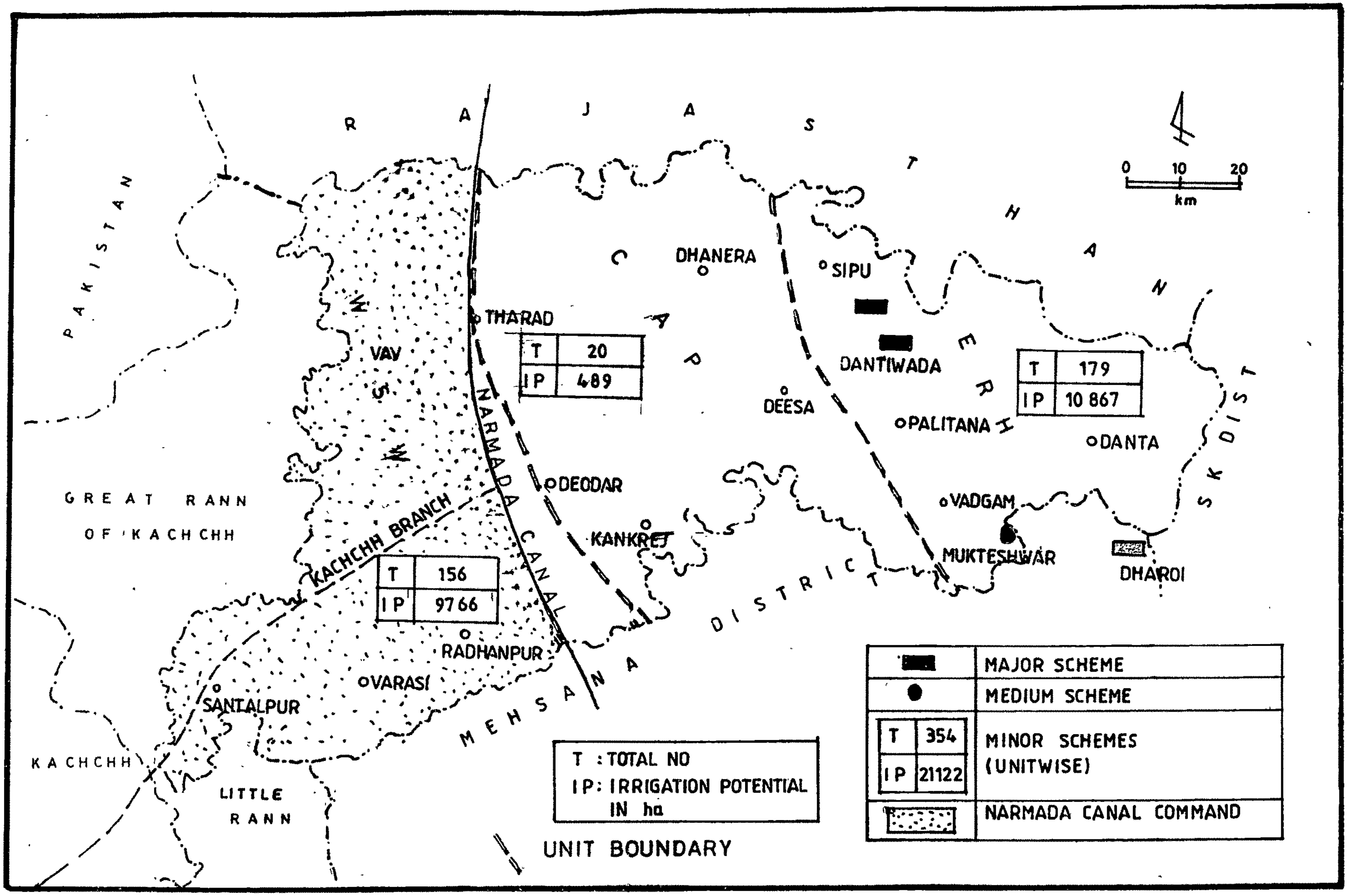

FIG-7·1 IRRIGATION MAP OF BANASKANTHA DISTRICT

DEVELOPMENT AND MANAGEMENT

The natural availability of surface water is confined to a few rainy days during monsoon, is required to be harnessed to meet the year round needs. The demand for water has resulted into a variety of resource development methods. Banaskantha has a long history of the surface water resource development. Field studies of the existing sources in the form of ponds and canals indicate that the district has rich tradition of surface water harnessing More indigenous and terrain appropriate structures have been observed to be in use since more than a century. However, this practice was mainly limited for the domestic needs. As a part of the national campaign for 'grow more food' taken up immediately after the independence, a massive programme of irrigation was introduced in the district also. As a result there was a sudden influx of water resources harnessing activity by constructing dam reservoirs and groundwater extraction through deep tubewells. Though the programme in the district did realize the goal, but it unfortunately caused significant geoenvironmental deterioration.

The pre-independence development practice was mainly in the form of pond storages, river flow diversion canals, dug wells and step wells. These used to cater to the local needs, and the management was done by community or individual users. While the modern development mode emphasized on mega-size, centralized operation and managed by the Governmental agencies. The various methods and techniques of surface water resources development have been briefly described.

PONDS

The inland water bodies in the form of ponds and tanks are the known traditional structures of surface water sources. An assessment of the existing ponds in terms of size, depth, capacity and use has been made by the present author through actual site investigation in the various parts of the district. The locations of the ponds indicate a special micro-geomorphic conditions. Most of the ponds are related to the relicts of the natural drainage pattern of the recent past. The abandoned channels and local depressions have been taken advantage to develop them into storage ponds by constructing earthen bunding, bed excavation, guiding the local runoff to fill it, the excess runoff to feed other ponds by gravity flow at lower levels. The village people used to regularly maintain the ponds by desilting, bank strengthening, and cleaning the catchment and inlet arrangement. There used to be provision of proper safety arrangements against breaching by providing spillover and diversion of excess water in the past traditions.

The average size of a village pond is about 2 to 3 ha but the larger ponds of 20 to 30 ha size are also not uncommon. Average depth is about 2 to 3 m, however, some ponds of depths of 5-6 m are also found. The larger size ponds over 3 ha size and 3 m depth generally store water round the year. The pond seepage forms a local groundwater recharge mound that supports the shallow dug wells in the close vicinity (Fig 7.2).

A statistical analysis of the ponds has been attempted from the information available on the Survey of India (SOI) Toposheets (1:50,000 scale). The details in terms of size, depth, location, etc. were collected for the ponds having size of 1 ha and more. The study on the SOI topographic sheets of years from 1957 to 1963 was carried out. A comparative summary in respect of the ponds in the three geo-environmental units is presented in the Table 7.8.

Table 7.8 Geoenvironmental unitwise details of ponds

Unit	Total Nos (%)	Aggregate Area coverage ha (%)	Gross storage capacity ha-m (%)
ERH	55 (7)	150 (5)	146 (5)
CAP	374 (46)	913 (28)	804 (27)
WSW	391 (48)	2177 (67)	2057 (68)
Total District	820 (100)	3240 (100)	3007 (100)

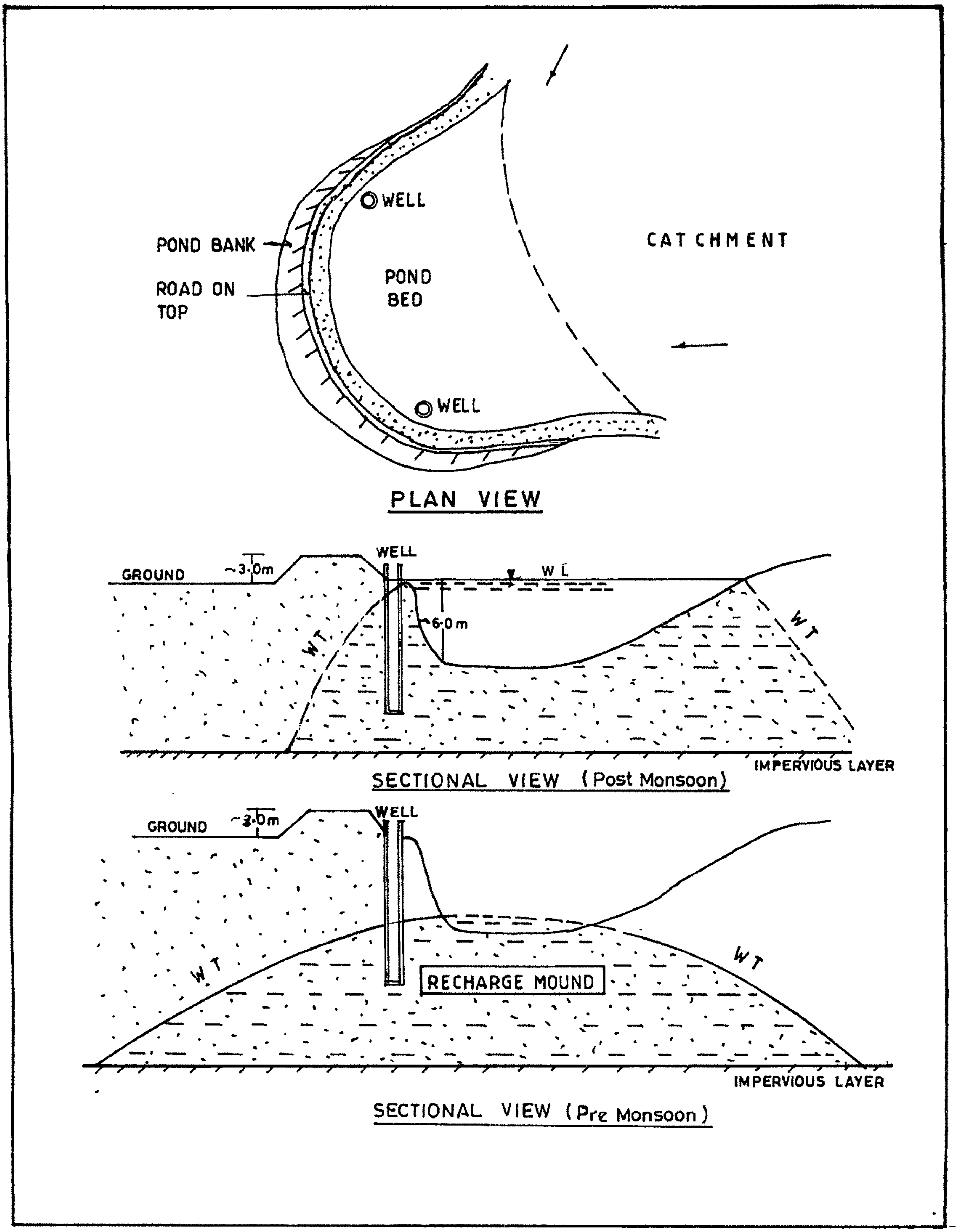

FIG-7.2 SCHEMATIC DIAGRAM OF POND INDUCED GROUNDWATER RECHARGE MOUND

The comparison shows a distinct discrepancy in the three geoenvrionmental units. ERH terrain relatively has less number of surface water bodies as compared to the other two areas which reflects the terrain conditions and pattern of the water needs of the local people. The WSW unit has maximum of ponds in comparision to the other two units. It is interesting to observe that WSW unit has got highest area coverage and storage capacity. Low rainfall and salinity of the groundwater are the characteristics of WSW unit, so the ponds in this area obviously forms a dependable source of fresh water supply.

CANALS

The district has a rare distinction of surface water development by canal irrigation in existence for more than a century. As per the old Gazetteer records, during the erstwhile British rule, Mr. Scott, an English officer had introduced the scheme by diverting the Banas river flow in Radhanpur taluka into canals on its both banks. This water was used for irrigation and also for feeding the village ponds for other domestic uses (Plate 7.1). It is popularly known as 'Scott Canal' even today (Rajyagor et. al., 1980). The canals have been taken off from Kamalpur village on north bank and from Khakhal village on the south bank. The total length of the canals is more than 80 km and covers about 20 villages. The old SOI Degree sheet (1" = 4 mile, 1887) shows the canal layout (Fig 7.3). Presently, it is being maintained by the District Panchayat.

It is interesting to observe that the offtake points of the canals are located on the junction of CAP and the WSW units. After the Dantiwada dam construction, as there has been hardly any flow in Banas during post-monsoon period, the canal has more or less lost its main purpose of irrigation, and has remained neglected. In recent years however, the canal has been revived by desilting and cleaning weeds then diverting the monsoon

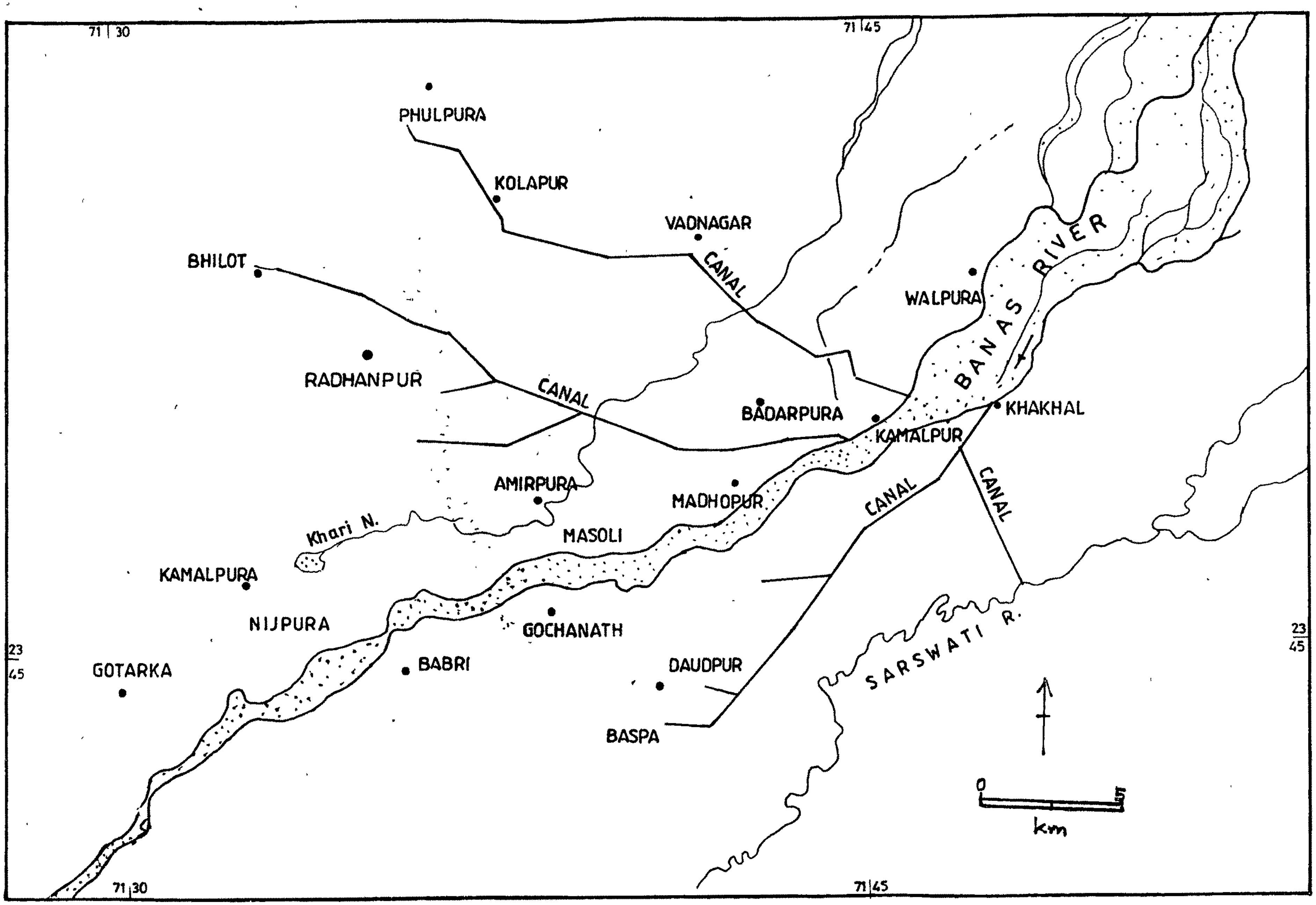

FIG-7.3 LAYOUT OF SCOTT CANAL

Plate 7.1 A view of Scott Canal (Loc. near village Bhilot).

flood flows for filling the village ponds. Thus, the historical canal system originally meant for irrigation is now being partly used as village pond feeder.

As has been mentioned earlier, the post-independence period witnessed an abrupt and extensive programme of water reources development all over the country. The district has though a limited surface water potential (942 MCM) available for harnessing, a large part (77%) of it has already been harnessed in several surface storage structures (WRD,1989). Almost entire surface water development in the district has been carried out by the State Government, Irrigation Department through major, medium and minor scale projects. The project catagerisation is genreally been made on the basis of irrigation capacity; major above 5000 ha, medium 5000 to 500 ha and minor below 500 ha (WRD,1989). In recent years, good contribution towards surface water development is also being made by the other public agencies like local Panchayats or Voluntry organisations.

MAJOR AND MEDIUM SCHEMES

The two major schemes, on rivers Banas ie. (Dantiwada) and Sipu (Sipu) and one medium scheme on Saraswati (Mukteswar) have been implemented (WRD,1989). Some important details of the schemes are given in Table 7.9. The schemes comprise storage reservoir dam and canal network for irrigation. These sites are located in ERH unit but the irrigation commands fall partly in CAP unit and partly in the adjoining district of Mehsana.

Table 7.9 Details of Major and Medium Schemes of the district

Details	Major		Medium	Total/ Average
River	Banas	Sipu	Saraswati	-
Project name	Dantiwada	Sipu	Mukteswar	03
Catchment area (sq km)	2762	1222	306	4290
Mean Annual Rainfall (mm)	940	885	907	910
Gross storatge (MCM)	464	178	40	682
Irrigation Command (ha)	58895	16000	6186	81081
Year of commissioning	1965	1995	1993	-

Detailed salient features of the four schemes are given in Annexure 7.3. The three schemes within the district together have a gross storage of 682 MCM and irrigation potential of 81,081 ha. However, paradoxically almost half of the irrigation benefits generated in Banaskantha go to the adjoining district. It may also be mentaioned here that a Major dam across Sabarmati, with 908 MCM storage at Dharoi (Mehsana district) is located just at the flank of the district but it does not get any benefit.

MINOR SCHEMES

The Minor schemes include different types of structures like small dam, checkdam, percolation-tank, underground-checkdam, lift irrigation and Aadbandh. In the district, there are as many as total 295 such schemes with an aggregate irrigation potential of 18,454 ha (TEC, 1995). Considering 50 cm irrigation depth the total storage capacity of the schemes would about 92 MCM. While 31 schemes on going which would create irrigation potenital of 971 ha and would have storage capacity of 5 MCM. Over and above this 27 more schemes with 1697 ha irrigation potential having storage capacity of 8 MCM are proposed for the district for development (TEC,1996). Geoenvironmental unitwise details of the existing, Ongoing and Proposed minor schemes are shown in Table 7.10.

In view of the terrain conditions, the ERH provides better locations for the schemes as compared to the other two geoenvrionmental areas of CAP and WSW.

Table 7.10 Geoenvironmental unitwise details of Minor Irrigation Structures in the district.

Unit	Schemes	Number of Schemes				Irrigation Potential (ha)			
		Exist-ing	On-going	Pro-posed	Total	Exist-ing	On-going	Pro-posed	Total
ERH	Minor Irrigation	38	02	08	48	7143	305	975	8423
	Checkdam	18	-	-	18	88	-	-	88
	Percolation tank	72	13	02	87	755	123	18	896
	Lift Irrigation	04	02	03	09	454	253	332	1039
	Underground-checkdam	-	02	11	13	-	84	242	326
	Aadbandh	03	-	-	03	95	-	-	95
	Sub Total	135	19	24	178	8535	765	1567	10867
CAP	Minor Irrigation	01	-	-	01	54	-	-	54
	Checkdam	-	-	-	-	-	-	-	-
	Percolation tank	09	02	-	11	154	02	-	156
	Lift Irrigation	-	-	-	-	-	-	-	-
	Underground-checkdam	01	-	02	01	30	-	-	30
	Aadbandh	06	-	01	06	249	-	-	249
	Sub Total	17	02	03	20	487	02	-	489
WSW	Minor Irrigation	03	-	-	03	1348	-	-	1348
	Checkdam	-	-	-	-	-	-	-	-
	Percolation tank	22	01	-	23	345	25	-	370
	Lift Irrigation	-	-	-	-	-	-	-	-
	Underground-checkdam	03	-	-	05	130	-	80	210
	Aadbandh	115	09	-	125	7609	179	50	7838
	Sub Total	143	10	-	156	9432	204	130	9766
District	Minor Irrigation	**42**	**02**	**08**	**52**	**8545**	**305**	**975**	**9825**
	Checkdam	**18**	-	-	**18**	**88**	-	-	**88**
	Percolation tank	**103**	**16**	**02**	**121**	**1254**	**150**	**18**	**1422**
	Lift Irrigation	**04**	**02**	**03**	**09**	**454**	**253**	**332**	**1039**
	Underground-checkdam	**04**	**02**	**13**	**19**	**160**	**84**	**322**	**566**
	Aadbandh	**124**	**09**	**01**	**134**	**7953**	**179**	**50**	**8182**
	Grand Total	**295**	**31**	**27**	**353**	**18454**	**971**	**1697**	**21122**