Chapter 1

Introduction

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Mankind depends heavily on the development and exploitation of natural resources for satisfying the escalating societal demands. Consequently nature cannot be preserved in an unaltered condition. Thus development of resources and environmental changes goes together. Developing countries, like India, facing population explosion, still it yearns for economic and social progress to catch up with the developed countries.

Gujarat, a predominantly agricultural based state. Owing to highly erratic and unevenly distributed monsoon, the exploitation of states' total water resources for irrigation, industries and domestic utilities had grossly overutilized. An increased pace in irrigation potential has brought up the stability in agricultural based production by reducing the effect of weather based fluctuation. This uncontrolled utilization of water and land has caused imbalance in natural environment, causing an irreparable damage to states' precious land and water resources.

This present study represents a case of one of such irrigation project i.e. Matar Branch of the Mahi Right Bank Canal (MRBC) command in the Central Gujarat.

AIMS AND OBJECTIVES

Presented study aims at evaluating the consequences of canal irrigation and its impact on soil and water regimes; corroborating secular and the vector changes in water table, water chemistry and the salt balance in soil and sub-soil horizons. The information thus generated to be utilized for conceptualising and suggesting appropriate management strategies, to mitigate the adverse effects.

The main thrust of the investigation pertains to a critical evaluation of the following parameters:

- ✓ Surface and subsurface geological conditions, sediment nature and extent,
- ✓ Basic terrain characteristics, landuse pattern and long term changes,
- ✓ Water table behaviour pattern – secular and vector changes and its causes,
- ✓ Canal water input and its contribution to groundwater regimes as return irrigation seepage,
- ✓ Soil-water chemistry vis-a-vis secular and vector changes,

- ✓ Surface and sub-surface outflow and the factors governing the outflow.
- ✓ Crop-water demand scenario and existing management practices.

APPROACH AND METHODOLOGY

A multi-disciplinary approach was adopted to achieve the above-cited objectives. The methodology thus followed:

- ➢ Collection of existing geohydrological data pertaining to the study area, to be used for working out long term and spatial changes in the command area in general and Matar Branch specific.
- ➢ A detailed fieldwork carried out to delineate the effect of irrigation on soil and water regime, change in land use pattern using satellite data and the field checks.
- ➢ Inventory of groundwater table changes for different seasons on identified observation wells and groundwater sampling.
- ➢ Collection of soil samples from surface and sub-soil horizons.
- ➢ Determination of physical and chemical characteristics of the water and soil samples.
- ➢ Data evaluation – graphical and statistical treatments for establishing geohydrological regime, groundwater flow maps and spatial distribution of soil-water chemical content.
- ➢ Working out an appropriate management strategy to minimize the geo-environmental hazards.

CLIMATE

Gujarat is in the region of seasonal climate. Its climate is between the Southern Indian Konkan climate of heavy rain and dry climate of Rajasthan. South Gujarat is blessed with 200 cm rain whereas 30 to 40 cm rain falls in Banaskantha district in North Gujarat (Figure 1.1). On the Western side Kachchha district climate is hot and dry, and on southeastern region, Dang district and part of Valsad district is a dense forest. Thus Gujarat is experiencing inequality of temperature and rain during the year. This inequality may be attributed to the geographical location of Gujarat and nearby sea. The climate of the Mahi Right Bank Canal (MRBC) Command Area is semi-arid. It is characterized by hot summer and general dryness, except during the southwest monsoon season which experiences heavy rain. There are four distinct seasons in this area. The cold season from December to February is followed by hot summer from March to the Middle of June. The

period from Mid June to September is Southwest monsoon season. October and November is characterized by post-monsoon season with moderate temperature and scanty rain.

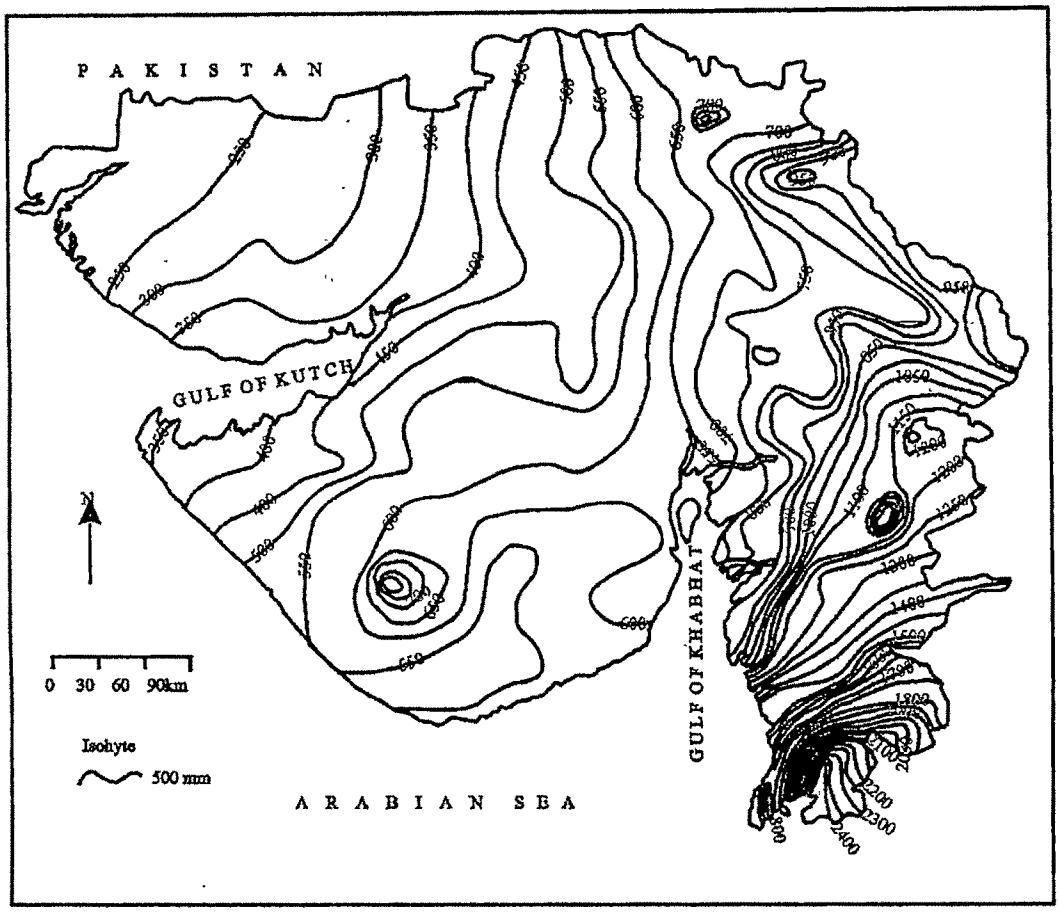

Fig. 1.1 Isohyet Map of Gujarat

RAINFALL

The average rainfall of command area is 830 mm spread over 35 days. About 96 % of the rainfall is received during the southwest monsoon period. The area suffers substantial variation in the annual rainfall from year to year. The highest rainfall (1725 mm) about 233 % of normal occurred in 1927 whereas the lowest rainfall (250 mm) less than 80 % of the normal has occurred in the year 1917.

TEMPERATURE

The information on temperature presented under this title is based mainly on the records of the observatory at Vadodara and Anand. It may be seen that the period from March to May there is continuous increase in temperature. The hottest month is May with

mean daily maximum temperature of 41^0 C and mean daily minimum temperature 26^0 C. The weather is intensely hot in summer and during same period the temperature occasionally reaches to 47^0 C or more. January is generally the coldest month with the mean daily maximum temperature of about 30^0 C and mean daily minimum temperature of about 11^0 C. Cold waves sometimes occurs as a result of passage of disturbances across North India. During this time the minimum temperature reaches to 2^0 to 3^0 C

HUMIDITY

During the Southwest monsoon season, the humidity is generally high. But during the period of April to June is the driest part of the season when relative humidity is 46 to 91 % in morning and 16 to 75 % in the afternoon.

WIND

Winds are generally light during most of the months in the year, ranging from 2.6 km/hr to 9.8 km/hr. However, the summer months experience comparatively strong winds. The wind direction varies from west to southwest during monsoon and northeast to north during summer.

A special weather phenomenon experienced in command area is the occurrence of gusty winds and widespread rain in some years during post-monsoon season. These are associated with cyclonic storms originating from the Arabian Sea. Some times such rain may occur during pre-monsoon period.

PHYSIOGRAPHY

The district can be divided into four geomorphic zones (1) The moderate relief area in the north, (2) Piedmont zone (3) The alluvial plane, and (4) Coastal sub-marine zone. The moderate relief zone occupies the northern and northeastern border area of the district and is characterized by an undulating terrain where linear ridges as well as isolated hills with steep slopes occur here and there. All along the periphery of this zone, sloping towards the deeply incised by streams and having a slope towards south and southwest. This zone has also got the sand whalebacks and mounds which merge into a sand sheet covering the alluvial plain in their vicinity. The alluvial plain is monotonously flat with large rivers cutting deep into it. It comprises thick, weathered older and newer alluvium. On the both banks of the rivers, there are fluvial terrace and deep gullies, which

are advancing headwards. There are extensive reddish sand pockets all over the plain. This is the most fertile area of Gujarat.

The alluvial plain merges into the coastal zone in south. The coastal zone is characterized by prominent out banks along Mahi's mouth, which lose its height towards west, and near Cambay it merges into the wide tidal flat. On the coast, there are coastal sand dunes, which are partially stabilized.

The drainage pattern in the area is inherited from the cycle of down cutting in streams with stream flow controlled by structural faults. At present erosion seems to be in mature stage. The major competent streams are Mahi, Sabarmati, Shedhi and Watrak. There are smaller tributaries and nalas, which follow the general trend of slope. The highest point of the area is 350 ft above MSL near Wanakbori and the lowest point is less than 50 ft. above MSL around Cambay.

GENERAL GEOLOGY

Present study area forms a part of the intra-cratonic Cambay basin belonging to the Mainland Gujarat. Cambay basin falls between the latitude 21^0 to 24^0 N and longitude 71^0 30' to 73^0 30' E respectively.

The rocks of the mainland shows an age from Proterozoic to Recent, but the most striking feature of the stratigraphy of the mainland is total absence of entire Paleozoic sequence and the development of only upper most Mesozoic rocks.

The present study area falls under the Tarapur-Cambay block, and exhibit litho-stratigraphy as Table 1.1 (after Pandey et. al. 1993).

LAND DISTRIBUTION AND UTILIZATION PATTERN

The land distribution pattern in the MRBC command area in terms of the size of holdings is highly skewed. There are 2.2 lakh land holdings. About 19 percent of the total land are holdings of size less than 1.0 ha and held by about 56.2 percent of the land holders. About 4 percent of the land holdings are larger than 6 ha and vover 22 percent of the total land. The culturable command area of the project is 2.13 lakh ha, of which 1.39 lakh ha is served by MRBC irrigation system by 1997 – 98 constituting 65.39 percent of the culturable command area.

Table 1.1 General geology of the Tarapur - Cambay Block

Period	Formation	Thickness in m	Lithology
Recent to Pleistocene	Gujarat Alluvium	50-100	Yellow Grey Sandy Clay
	Jambusar	300	Yellow Grey Clays, Coarse Sand, Gravel and Kanker
Pliocene	Broach	300	Chocolate Brown and Red Brown Clay Stone, Sandy Claystone and Sandstone
Up. Miocene to Mid. Miocene	Jhagadia	200	White and Gray Calcretes and Micaceous Sandstone, Gray Shaly Sandstone and Sand
Mid. Miocene to Lower Miocene	Babaguru	300	Ferruginous Sandstone, Conglomerate and Gray Clays and Claystone
Lower Miocene	Tarkeshwar	150	Variegated and mottled claystone and Sandstone, Carbonaceous, Sideritic Shale and Sandstone.
Oligocene to Up. Eocene	Tarapur Shale	200-300	Greenish Grey to Dark Grey Shale, Silty and Sandy Shale, Argillaceous Sandstone
Up. Eocene to Mid. Eocene	Vaso	200-300	Sandstone Calcareous, Silty Shale,
Lower Eocene	Upper Cambay Shale	500-750	Dark grey to grey Shale moderately hard, massive sand, Sandstone, Carbonaceous, dark grey Shale and Coal
Paleocene	Lower Cambay Shale	500-750	Dark Grey to Black fissile shales, hard and rich in organic matter
Upper Cretaceous	Deccan Trap	300-3000	Basalt, Andesite, Trachyte, Picrite and Syenite etc.
Proterozoic	Granite		

TRANSPORT AND COMMUNICATION

The MRBC command area has comparatively well developed road facilities. The growth of milk cooperatives led to the development of roads and virtually all villages are connected by roads, with near by marketing centres or with other villages which are linked with marketing centres. About 45 percent of the villages are provided with bus faiclites during winter and summer seasons. Almost all the talukas, except Matar talukas, are served by broadgauge railway lines. About 70 percent of the villages in Kaira district are covered by post and telegraph communication facilities.

MAHI KADANA IRRIGATION PROJECT

The Mahi Kadana irrigation project has been developed in two stages. The first stage comprised the construction of diversion weir across the River Mahi at Wanakbori village in Balasinor taluka of Kaira district in Gujarat. The weir was completed in the

year 1958. It facilitated the diversion to the River flow to the canal system with negligible storage in the upstream of the weir. The second stage of irrigation development comprised the construction of a major reservoir in Santrampur taluka of Panchamahals district of Gujarat. It is located 70 km upstream of the Wanakbori weir (Fig 1.2, Plate I 1). The Kadana reservoir, known as Mahi Stage II, was constructed in the year 1978 with the primary objective of augmenting the supply of water to the Mahi Right Bank Canal command area. While the Wanakbori weir system was built primarily to provide supplemental irrigation for monsoon crop, the Kadana reservoir system was designed to store and supply irrigation water for the winter and summer crops in the same areas served by the Wanakbori weir system. After the completion of the Kadana reservoir, assured water supply has been made available in the MRBC command areas and an irrigation potential of 2,63,000ha has been created.

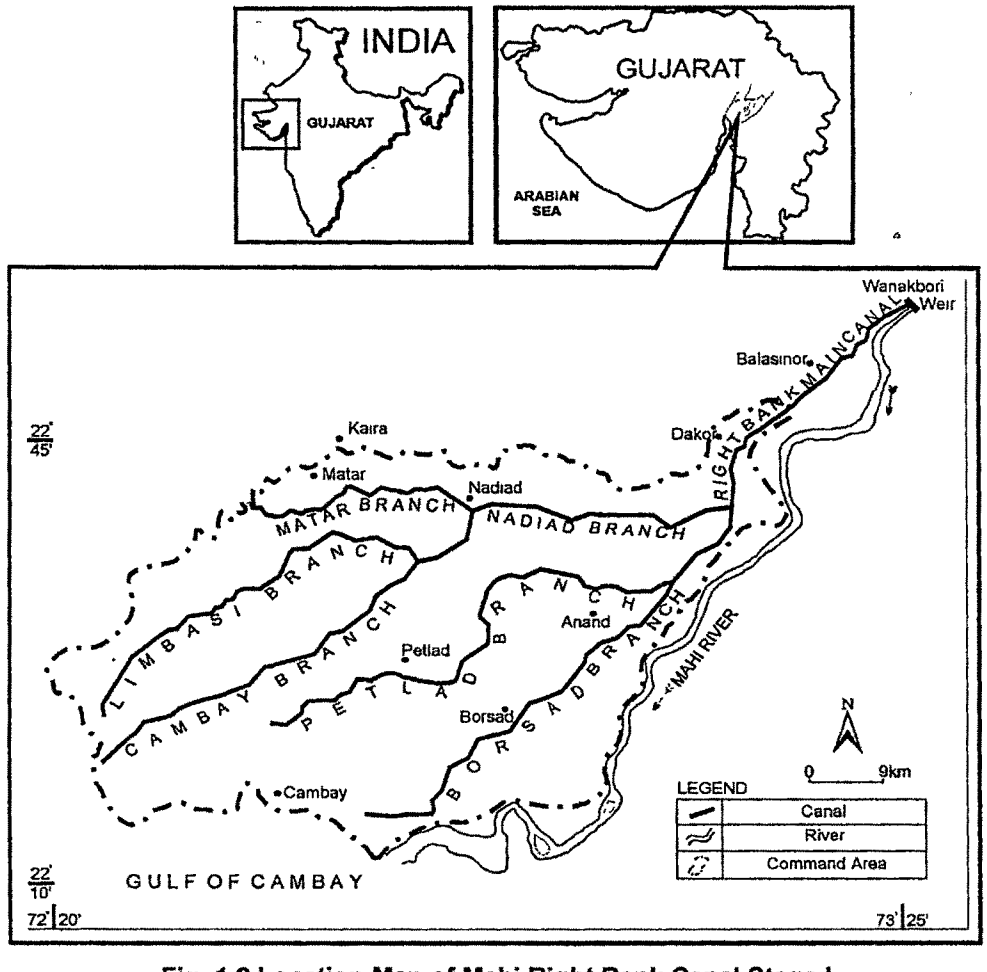

Fig. 1.2 Location Map of Mahi Right Bank Canal Stage I

Plate I-1 Close View of Wanakbori Weir.

The water from the Kadana reservoir is released into the Mahi River and is carried downstream to the Wanakbori weir. The natural course of the River itself is used of the conveyance of the releases. The ungated Ogee shaped weir on the river Mahi at Wanakbori was constructed as a pick-up weir. It is a masonry gravity structure about 800m long of which overflow section is 670 m. The weir is founded on a hard rock formation. The maximum height of the weir above the river bed is 20.6 m with the R. L. of top at 67.23 m. the design flood discharge over the weir is 4700 m^3/sec. The salient features of the weir are given below.

General:

1. Location of weir	:	Wanakbori Ta. Balasinor, Dist. Kheda.
2. Latitude	:	22^0 56
3. Longitude	:	73^0 25'
4. River	:	Mahi
5. Purpose	:	Irrigation
6. G.C.A.	:	3,15,790 ha.
7. C.C.A.	:	2,12,694 ha
8. Year of commencement	:	1948
9. Year of completion	:	1958

Hydrology:

1.	Catchment area	:	30,665 sq.km.
2.	Nature of river	:	Perennial
3.	Nature of catchment	:	Hilly, forested and double fanned
4.	Average annual rainfall	:	880 mm.
5.	Highest flood level at weir	:	75.89 meter
6.	Maximum flood discharge of river	:	41064 cumecs
7.	Design flood discharge	:	46728 cumecs

Pick up weir:

1.	(i) Over flow section	:	673.80 m.
	(ii) Partial overflow	:	60.97 m.
	(iii) Non partial over flow	:	60.97 m.
	(iv) Total length	:	795.74 m.
2.	Type of weir	:	Ogee shaped gravity section built on random rubble masonry.
3.	Crest R.L. of weir	:	69.234 m.
4.	Height of weir	:	20.60 m.
5.	Calculated H.F.L. over pick-up weir with afflux	:	76.50 m.
6.	No. and size of scouring Sluices	:	10 nos. of 3.05 m X 3.66 m.
7.	Head regulator		
	i. Type of gate	:	Radial gates
	ii. Nos. and size of gates	:	7 nos. of 6.10 m X 3.66 m.
8.	Flood embankments		
	i. Top level	:	79.55 m
	ii. Length		
	a. Right bank	:	914.40 m
	b. Left bank	:	2072.64 m
	iii. Free board of the	:	3.05 m
	iv. Top width	:	3.65 m
	v. Side slopes		
	a. Water side	:	2:1
	b. Non-water side	:	2:1
9.	Canals		
	a. Main canal		
	i. Length	:	73.60 km.
	ii. Capacity	:	198.10 cumecs
	iii. Type of canal	:	Lined
	iv. Section	:	16.46 m X 5.18 m and 15.24m X 0.90 m.
	v. Bed gradient	:	1:7000 and 1:5000
	vi. Canal slope	:	1.5 in 1.
	b. Branch canals		
	a. Total length	:	223 km.
	i. Lined	:	218 km.
	ii. Unlined	:	5 km.
	c. Distributories, Minors & sub minor	:	2362 km.

The irrigation scheme developed with the facility of pick-up weir at Wanakbori has primarily intended to be a supplementary irrigation scheme during the monsoon (kharif) season. The Mahi command area has been divided into land irrigability classes depending upon soil and drainage conditions. The irrigation is provided in whole command in kharif, while in rabi and hot season, the effective command area is curtailed to 1.3 lakh ha, as command consisting of class III and IV soils is not provided irrigation in rabi and hot weather season. The scheme was designed to create an irrigation potential of 1,86,000 ha. This included areas irrigated by the canal system and a few tanks in Matar and Cambay Taluka.

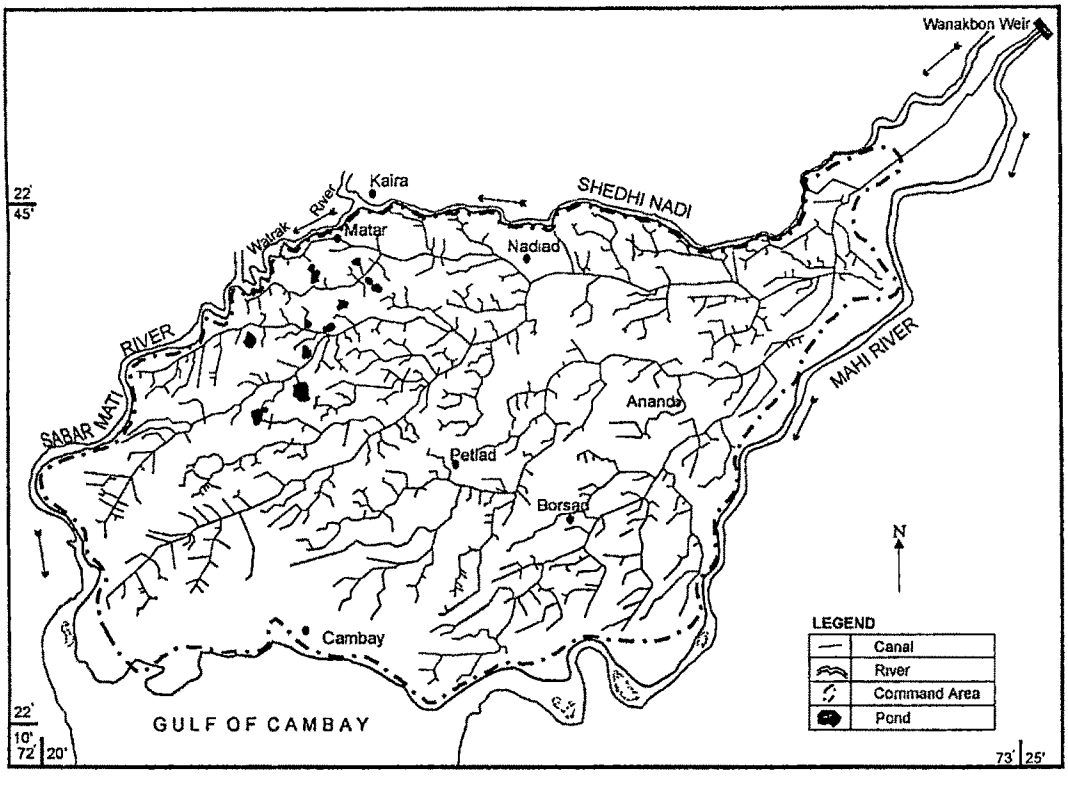

Fig. 1.3 Canal Network in Mahi Right Bank Canal Command Area. (Source: MIC, Nadiad)

The MRBC system (Fig. 1.3) comprises main canal, a number of branches, distrubutaries, minors and sub-minors. A number of outlets take off from the canal system. Details of the canal system are given in the Table 1.1.

Table 1.1 Salient Features of the Canal System in Mahi Right Bank Canal Command Area

Sr. No.	Name of Distry	CCA 'ha'	Design Discharge 'cusecs'	Length of Distry 'km'.	Length of Minors & SM 'km'.	Total Length 'km'.	Max.Ann. Irri. Int. '%'	Max. Kharif Irri. Int. '%'	Major crops Kharif/rabi/hot
MAIN CANAL									
1	Shapura	1071	53	4.57	9.86	14.43	141.18	74.85	P/W/B,GN
2	Umreth	2532	128	11.46	20.89	32.35	136.25	69.07	P/C-T/B,GN
3	Rania	665	53	6.92	9.45	16.37	151.55	59.67	P,C-T/C-T/B,GN
4	Kherda	1964	36	6.56	1.72	8.28	103.44	46.47	C-T/C-T/B
5	Vasad	2253	143	12.38	13.21	25.59	107.76	40.52	C-T/C-T/B
NADIAD BRANCH									
1	Bharoda	2764	79	10.17	26.55	36.72	95	38.63	C-T/C-T/B
2	Pansora	3461	169	11.16	36.71	47.87	125.18	59.33	P/C-T,W/B
3	Boriavi	3627	152	15.38	13.16	28.54	55.55	25.2	P/C-T.W/B,GN
4	Surasamal	3349	110	7.19	27.86	35.05	69.16	32.11	P,C-T/W/B,GN
5	Uttarsanda	2807	105	7.08	21.47	28.55	56.333	27.64	P/C-T/B
6	Nadiad	2219	49	4.62	19.93	24.55	54.22	23.72	P/C-T/B
PETLAD BRANCH									
1	Sarsa	928	54	5.18	6.71	11.89	84.96	38.51	C-T/C-T/B,GN
2	Chikhodra	2850	68	11.39	21.2	32.59	94.87	35.33	P,C-T/C-T,W/B,GN
3	Lambheval	1069	43	8.3	10.97	19.27	66.31	24.48	P/W/B,GN
4	Ghuteli	2586	51	11.67	12.24	23.91	63.41	22.94	P/C-T,W/B
5	Virol	5090	106	7.86	43.54	51.4	74.3	27.62	O/0/B
6	Manej	7303	360	27.38	52.69	80.07	103.42	56.85	P/W,O/GN
7	Jalsan	3824	140	19.95	13.92	33.87	85.04	47.1	P,O/W,O/B,GN
8	Tail	4374	160	11.05	25.91	36.96	50.4	28.7	P,O/W,O/B,GN
BORSAD BRANCH									
1	Anand	4980	93	8.19	27.24	35.43	59.61	20.58	P,C-T/C-T,W/B,GN
2	Adas	6660	180	7.94	50.76	58.7	58.8	20.81	P,C-T/C-T/B,GN
3	Anklav	5179	122	11.61	46.88	58.49	62.56	22.09	PE,C-T/PE,C-T/PE
4	Borsad	2990	62	13.15	11.33	24.48	72.52	27.75	P/C-T,W/B,GN
5	Alarsa	3479	68	11.96	14.6	26.56	46.23	20.09	P/C-T,W/B
6	Zarola	2110	60	11.58	14.57	26.15	77.41	39.01	P/W/B,GN
7	Dehwan	7869	183	11.04	37.83	48.87	106.94	37.12	P/W,C-T/O,GN
CAMBAY BRANCH									
1	Mahelav	3182	170	7.98	27.48	35.46	39.08	23.99	P/W/B,GN
2	Dabhou	2545	90	4.65	30.69	35.34	114.99	71.6	P/W/B,GN
3	Sinjiwada	3333	180	8.1	35.41	43.51	109.39	69.53	P/W,O/B,GN
4	Mahiari	3268	150	8.65	27.91	36.56	151.29	91	P/W/B,GN
5	Chikhalia	2875	116	11.7	23.21	34.91	179.32	100	
6	Sansad	3444	150	5.09	35.7	40.79	214.27	100	P,B,O/B,W,O/B
7	Lunej	1160	80	9.09	3.89	12.98	112.22	85.57	P/B,W/-
8	Bhal	7463	248	20.18	54.19	74.37	85.25	77.15	
9	Dehda	2588	111	9.58	14.2	23.78			

LIMBASI BRANCH									
1	Limbasi	10685	300	13.71	18.76	32.47	183.04	100	P,C-T/O,W/-
2	Golana	7665	235	20.45	75.04	95.49	97.94	74.34	O/W
MATAR BRANCH									
1	Traj	3896	200	19.81	40.57	60.38	147.99	100	P,C-T,O/O,W/B,GN
P= Paddy, PE= Perennials, C-T= Cotton/Tobacco, W= Wheat B= Bajri O=Other,									

The main canal and branch canals are lined by sandwich brick tile lining, while the remaining system is unlined. The water distribution system consists of number of cross regulators and escapes making the system 'articulated'. The operation of the canal system is done through three stages: processing of indents for irrigation water, release of canal water and, closure of canal.