2 STUDY AREA

Gujarat State is situated between 20^0 06' and 24^0 42' North Latitudes and 68^0 10' and 74^0 28' East Longitudes in the western part of India. It covers a total geographical area of 1,95,984 km^2 Out of the total area nearly 1,09,314 km^2 is occupied by rocky formations and 86,670 km^2 is by alluvium; of which 34,625 km^2 is saline area. The State has the longest coastline in the country measuring about 1,600 km along the western part of India, extending from Lakhpat in the North to Valsad in the South. Gujarat State has common borders with Rajasthan, Madhya Pradesh and Maharashtra States in North, East and South respectively and with Pakistan in the North-West.

The drainage in all areas of Gujarat has a distinct manifestation of the topographical features and physical characteristics of the rock formations. The flow directions of some of the major rivers are controlled by the major tectonic activities, which occurred during geological times. Except Narmada, Tapi and Mahi rivers, all other rivers In the eastern part of the state, originate on the western slopes of the eastern hills. They flow in the direction almost at right angle to the boundary i.e. towards southwest (Sabarmati and Mahi rivers) in the northeastern part, towards almost west (Narmada, Tapi, and Dhadhar) in the central region and towards northwest (Kolak, Par, Ambica, etc.) in the southern part. Most of the rivers in the alluvial plain meander with very wide courses whereas those in rocky tracts have deep and narrow courses. The rivers in Saurashtra and Kachchh originate from the Central uplands and represent a radial drainage pattern.

Gujarat, being located on the Tropic of Cancer, falls in the sub -tropical climatic zone and a large part of the state lies between 35^0 C and 45^0 C isotherms. The rainfall in the state is moderate. It forms a transitional zone between the heavy monsoon area of Kokan in the south and arid areas of Rajasthan in the North. Climatic conditions vary greatly in the state. The

climate in general has three main seasons i.e. summer, monsoon and winter. The monsoon breaks by middle of June, reaches its peak in July and starts retreating by end of September. The overall climate is humid, sub-humid and semi-arid to arid. The relative humidity in all parts of the State, except the coastal strip, is low (being about 50% between October and May). Average annual relative humidity figures for different regions are as follows:

- South Gujarat : 71%
- North Gujarat : 64%
- Saurashtra & Kutch Uplands : 56% to 67%
- Coastal Saurashtra : 69% to 77%

Wind velocities are generally moderate except during the period prior to onset of monsoon and during the monsoon period. Winds blow from west or southwest during monsoon whereas they blow from north -east during winter.

The study area is located in Jhalod taluka of Dahod district. Machhan River is flowing from South-West to North-East direction. About 1300 rivulets meets and helps to get collection of rain water into the river. The location of catchment in country, state and district shown in Figure No.2.1 The catchment area for The Machhan River is shown in the Figure No.2.2

The nearest railway station to reach the taluka place is Dahod, which is about 35 km from Jhalod. Jhalod is connected with district head quarter Dahod by State Highway-58.Jhalod is also connected by road with Kushalgadh and Banswada the prominent places of Rajasthan.

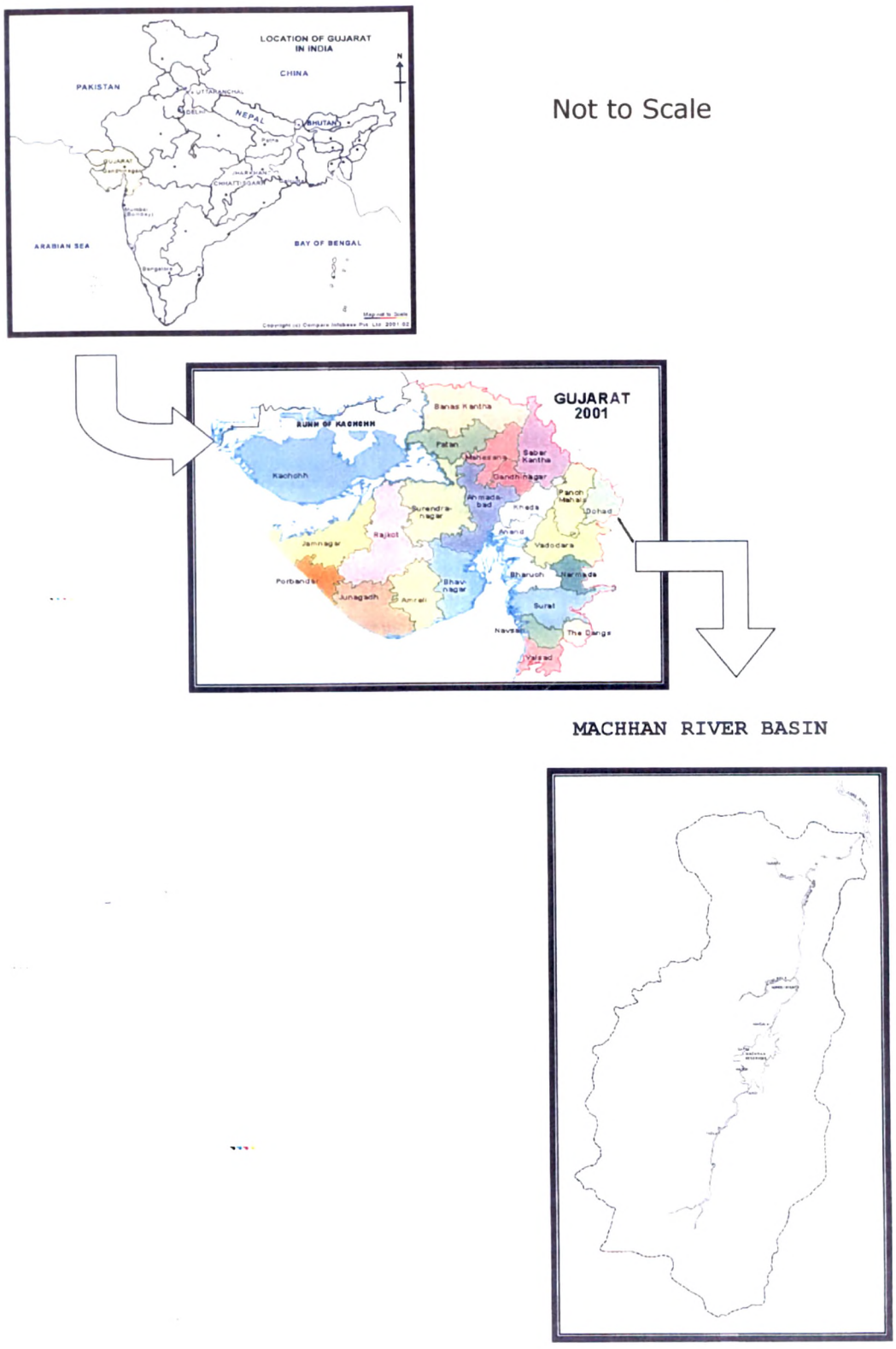


Figure 2.1: Location of Machhan Basin

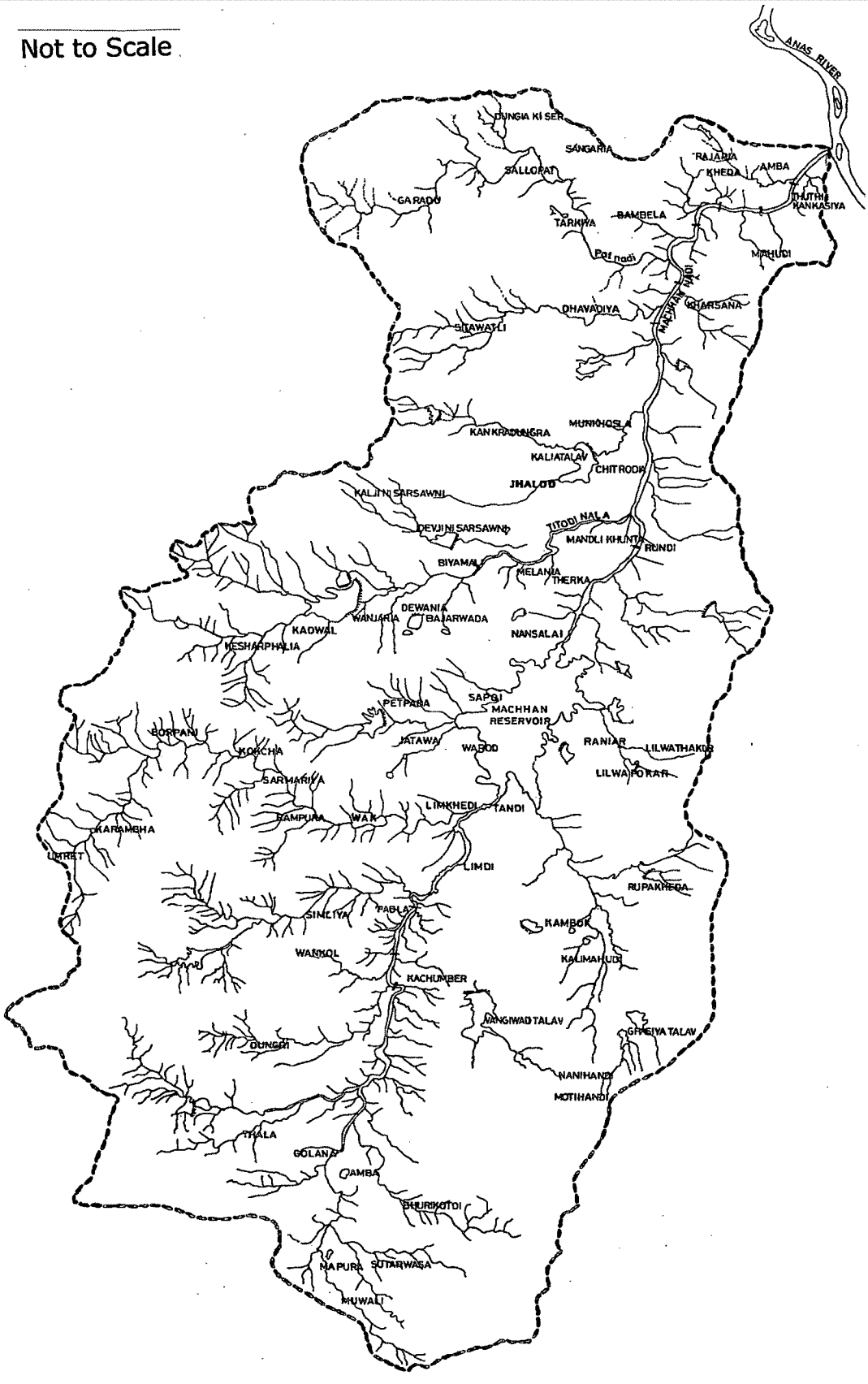


Figure 2.2 : Machhan River Basin

2.1 Geographical Location of Area

Panchmahal district lies between 20°30' to [-p23°30' north latitudes and 73°15' to 74°30' east longitudes. Dahod district is located in the North-east direction of Gujarat. Dahod was separated from Panchmahal district. Jhalod is one of the taluka places. The Machhan river is flowing through Jhalod taluka. Number of rivulets meets the Machhan River.

2.2 Topography of Area

The overall topography of the region from which Machhan river flows is highly undulating and of varying slopes. The catchment of the river is 431 km^2 up to its meeting place with Anas which is a tributary of Mahi. The elevations of the area vary from maximum 360 meter to minimum 200 meter with respect to mean sea level. Topographically the Machhan river basin can be divided in two parts.

1. Hilly area,
2. Flat agricultural land.

Western and southern part of basin comprises hilly region, while central part consist of flat agricultural land. The ground generally slopes from south-west to north-east.

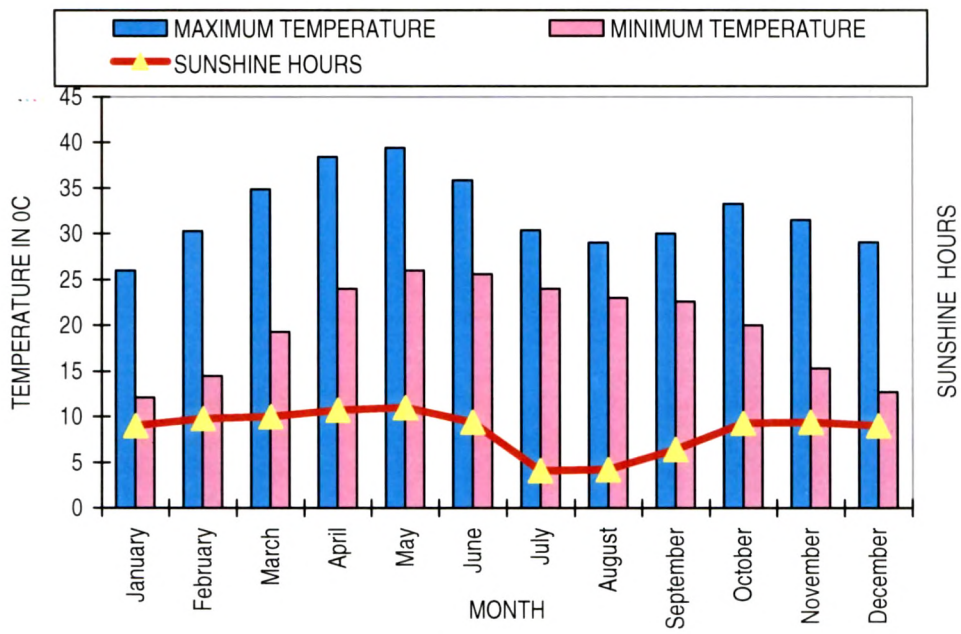
2.3 Climate of Area

Dahod district is moderately humid area. The minimum humidity observed in the month of March and April. The sunshine hours ranges between 11 hours to 4 hours. The various seasons of the year are,

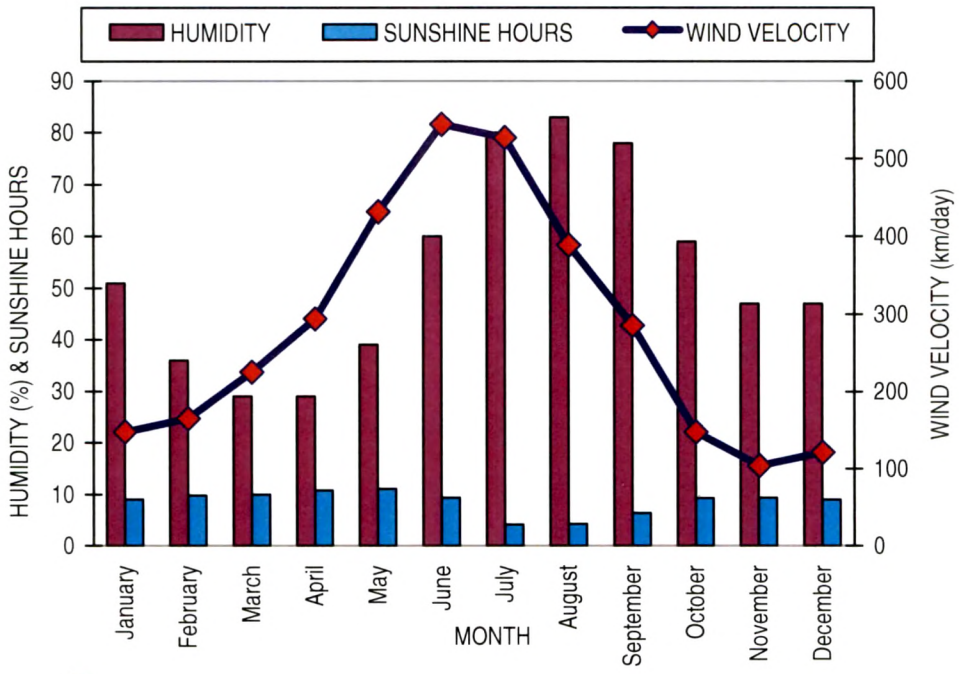
(a) Monsoon (Middle of June to middle of October),
(b) Winter (November to February) and
(c) Summer (March to June).

From March onwards the temperature starts rising till it reaches the maximum, as high as 45 ^{o}C . January is the coldest month of the year.

Machhan river catchment receives much of its rainfall from the southwest monsoon during the period between June and September, its maximum intensity being in the months of July and August. The annual rainfall in the area varies between 800 to 1000 mm. (Reference : Merh S. S., "Geology of Gujarat")



Graph 2.1: Meteorology of Machhan Basin
(Temperature & Sunshine Hours)



Graph 2.2 : Meteorology of Machhan Basin
(Humidity, Wind Velocity & Sunshine Hours)

2.4 Forest

In Dahod 1233.01 km^2 area is coming under reserved forest, 1.66 km^2 area is coming under protected forest and 22.74 km^2 area in unclassified forested. In Machhan river basin total forest area is about 28 km^2.

2.5 Geological and Hydrogeomorphological Set Up

2.5.1 Geology

Geologically the area is covered by compact metamorphic rock of Proterozoic successive belonging to Lunawada group of Aravalli Super Group. Quartzite and Phyllite belonging to Lunawada Group are encountered in study area.

The lithilogical characteristic suggest that the rocks represent shallow marine environmental depositions. The rocks have preserved sedimentary structures like laminating bedding, cross bedding and ripple marks. Along Quartzite and Phyllite, the South Western boundary is observed by a cover of Deccan trap and Infra trappen cretaceous rocks. The Deccan trap found in area is black in colour, weathered on top but becomes very compact at depth. It is formed due to volcanic activity.

Hydro-geomorphological conditions in the hard rock area are mainly controlled by the weathering conditions, cracks, fissures, joints and faults or lineaments etc. It also depends on the thickness of the overburden. To study the hydro-geomorphology of the area the remote sensing data of the various periods were studied and the area has been divided in to different categories as Buried Pediment (BP), Buried Pediment Shallow (BPS), Buried Pediment Medium (BPM), Denudation Hill (DH), etc. of Quartzite, Phyllite or Basalt.

Denudation Hill (DH)

Denudation Hills are observed in the few parts of the watershed area extending from Jetpur, Mandia to west of Sundhiya. They are formed due to differential erosion and weathering so that a more resistant formation or intrusion stands as monitoring hills. They have ground water prospects poor to nil.

Buried Pediment (BP)

A flat and smooth surface of buried pediment of Basalt, Quartzite or Phyllite with varying depths of overburden is noticed in the area. The pediments show increasing weathering towards Eastern side. This has resulted in different thickness of weathered and alluvial material over the pediment ranging from 0.5 to more than 20 m depending upon the thickness of overburden. It is classified in BP, BPS and BPM categories as follows.

BURIED PEDIMENT BP: In this unit the thickness of overburden is almost nil to 0.5 m. They have groundwater prospects poor to nil.

BURIED PEDIMENT SHALLOW BPS: In this unit the thickness of weathered and alluvial material over the pediment ranges from 0.5 to 5 m. The groundwater prospects in this area are poor to moderate.

BURIED PEDIMENT MEDIUM BPM: In this unit the thickness of the weathered and alluvial material over the pediment ranges from 5 to 20 m. The ground water prospects in this area are moderate to good.

(Reference: Merh S. S., "Geology of Gujarat")

2.5.2 Hydro-geological Condition in DH and BP

A ground water condition in the area depends upon the weathering condition of the basement rock and the overburden thickness. In general, the wells located in DH and BP can sustain from two to three hours in winter whereas in summer, it can run early for ½ to 1 hour and rate of recuperation is very slow even up to 24 hours. The depth to water level ranges from 2 to 5 m whereas total depth ranges from 5 to 10 m. In such areas, only large diameter wells are preferred as due to less thickness of overburden and compactness of rock of the aquifer will be poor and their transmissibility and permeability will be less they will act as a storage tanks.

2.5.3 Hydro-geological Condition in BPS

In the areas of BPS the groundwater, condition is moderate. In this case, the wells can have depths of overburden up to 5 m. The wells of larger diameter are preferred to achieve much better conditions. In this case, the wells can run for 4 to 5 hours in the winter and 1 to 2 hours in summer. The water level depths range from 2 to 5 m whereas total depths will be from 5 to 10 m. Only these wells are having more weathered rock and overburden so yields more quantity of groundwater. The aquifers in this case have little more transmissibility and moderate permeability.

2.5.4 Hydro-geological Condition In BPM

The wells located in this category can have good to very good yield as the weathered portion is more and thickness of overburden is more. In this category, the wells can run for 5 to 10 hours in winter and 2 to 5 hours in summer season. The water level ranges from 5 to 10 m. and depth varies from 15 to 20 m. The transmissibility and permeability of aquifer is more in this case and the rate of recuperation will also be fast.

2.5.5 Ground Water and Ground Water Level

The quality and availability of groundwater depend on rainfall, topography and hydro-geological setting. The catchment is coming under hilly zone of mainland of Gujarat. On the mainland, the hilly zones in the northeast provide an erratic groundwater scenario. Groundwater accumulates only in secondary porosity. Groundwater governed by zone of weathering, joint planes, cracks and fissures. Water table in these rocky areas varies from 4 to 10 m below the ground level and the aquifers are mostly unconfined.

In general the depth to water level in Jhalod taluka ranges from 1.2 to 21.5 m B.G.L. (Below Ground Level). In low laying areas along river banks mainly in central and north-eastern parts of the taluka, the water table is shallow between 2 to 8 m BGL. The depth of water level in south-western parts of the taluka varies between 6.5 to 21.5 m BGL. In general the depth of water levels broadly follows the surface topography and the drainage pattern in the area.

2.5.6 Hydrogeomorphological Information

Hydro geomorphologies of any region govern by weathering conditions, cracks, fissures, joints and faults or lineaments etc. It depends on the thickness of overburden. To study the hydro-geomorphology of the area the remote sensing data of the various periods were studied and the area has

been divided into different categories as Buried Pediment(BP),Buried Pediment shallow (BPS),Buried Pediment Medium (BPM),Denudation Hill(DH) etc. of Quartzite, Phyllite or Basalt. Exposed rock structure which is not covered by soil cover called as Pediment.

Different thickness of weathered and alluvial material over the pediment ranging from 0.5 m to more than 20 m depending upon the thickness of overburden. It is classified as BP (having overburden thickness almost nil to 0.5 m) BPS (having overburden thickness 0.5 to 5 m) and BPM (having overburden thickness 5 m to 20 m).The groundwater prospects in BP are poor to nil. It is poor to moderate in BPS and moderate to low in BPM. Groundwater conditions in the area depend upon the weathering condition of the basement rock and the overburden thickness. Details of Buried Pediment, Buried Pediment Shallow, Denudation Hill and Pediment are given in table No. 2.1, Fig.: 2.3

[Satellite imageries from IRS-II (Path Row 0030-052, Sensor A_1),IRS-IB(Path Row 0030-051 Sensor A_2),IRS-IC(Path Row 0030-056 Sensor A_1),IRS-1D(Path Row 0030-056 Sensor A_{1D})]

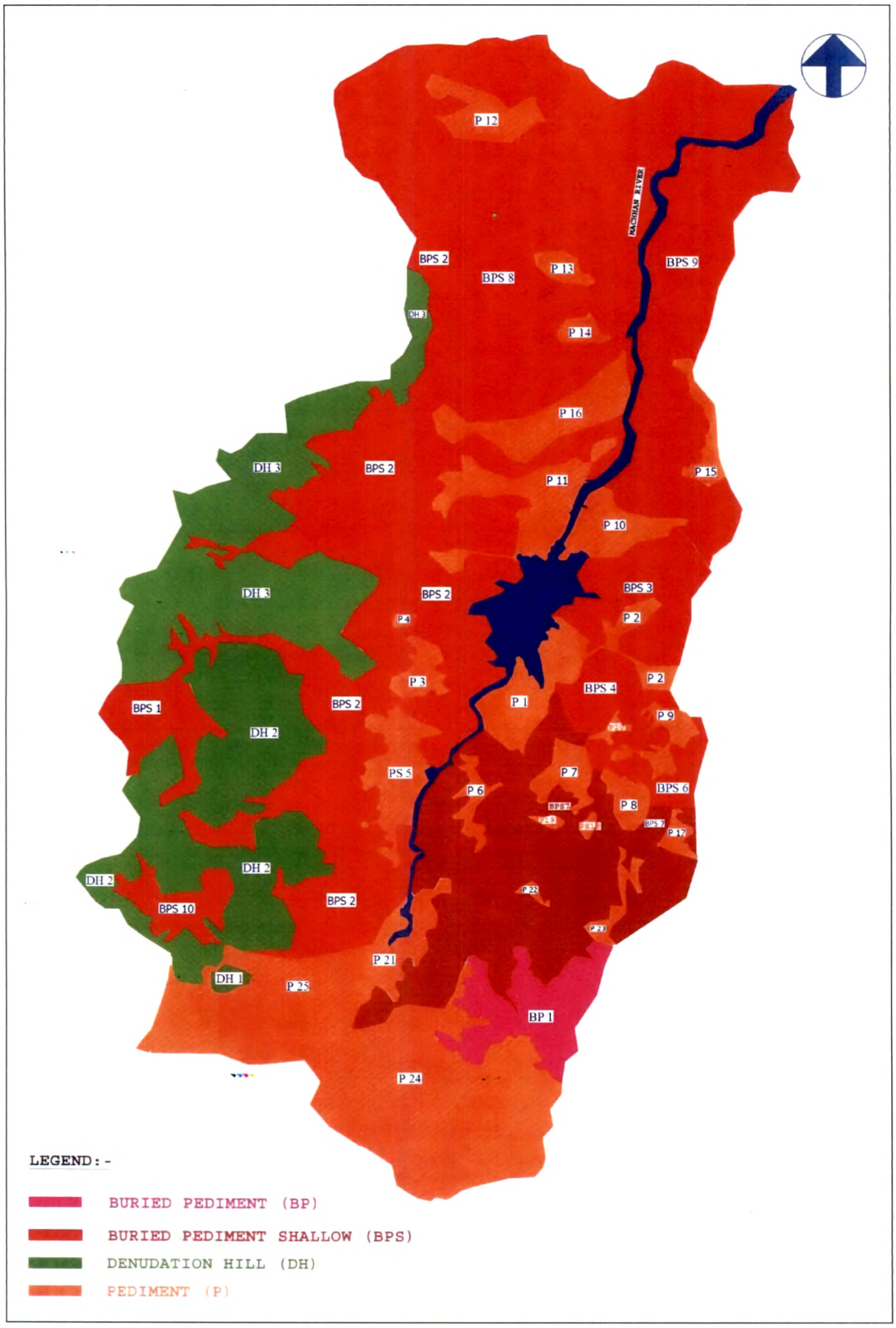


Figure 2.3 : Hydrogeomorphological Map of Machhan Basin

Table - 2.1: Hydrogeomorphological Details of Machhan River Basin

Designation	Area In Sq. m.	Designation	Area In Sq. m.
DH1	712081	P7	2138488
DH2	32598776	P8	1535420
DH3	32707542	P9	1722340
BPS1	6263816	P10	3755845
BPS2	73488774	P11	6862897
BPS3	9952363	P12	3593761
BPS4	3676452	P13	1159927
BPS5	35011034	P14	920697
BPS6	5371647	P15	1547950
BPS7	3641408	P16	6095480
BPS8	67595913	P17	724666
BPS9	27427375	P18	241375
BPS10	4341539	P19	246998
BP1	8887935	P20	366885
P1	4701344	P21	2053055
P2	2507009	P22	241483
P3	1788856	P23	1170298
P4	237973	P24	30775645
P5	5064161	P25	13833722
P6	1312420		
TOTAL			**406275350**

2.6 Soil in The Basin

In this region mainly three types of soils found,

- Sandy loam soil
- Medium black soil
- Black soil

These soils have been derived from weathering of underlying rocks. The sandy and sandy loam soils are mainly derived due to weathering of phyllite and schists rocks and black soil is derived due to weathering of Deccan trap rock. The soils are also derived from metamorphic rock viz. Phyllite, schists and slates and area laid in a ridge to valley formation. The general slope of the land is from south to north. The terrain is moderately undulating having slope range of 1 to 10 %.The density of natural drainage in the shape of rivers and streams is very good. The outfall condition is also considered as good. (Reference : "Reconnaissance Soil Survey Report Of Panchmahal", "Report of Machhan Nala Irrigation Scheme", and "Detailed Soil Survey Report", Machhan Nala Irrigation Scheme).

2.7 Flora and Fauna in The Basin

There are different varieties of plants found in the region. The nature varies according to the rainfall, altitude, soil, climate etc. The important fuel wood species indigenous to the region are Tectona grandis (Teak), Aracia Nilotica (Deshi-Bawal).The unusual species are Eucalyptus Tereticornis (Nilgiri), Prosopis Juliflora (Gando-Bawal).The fruit trees are Mangifera indica(Ambo), Phyllaanthus Embica (Amalo),Zizyphus Mauritiana(Bordi).The important medical plants include Withania Somnifera (Ashwagandha),Datura innoxa (Kalo Daturo).Important oil-seed trees, class found are Madhuca India (Mahudi),Derris indica (Karanj) and Azadirachta indica (Limdo).

The chief domestic animals are cow, buffalo, sheep, goat, donkey, horse and camel. Vital wild animals of cat family, Panther found in the area. The wolf, Jankal and fox, representatives of dog family, also reside in the forest part of Jhalod. Sambar, Indian gazelle, Black buck, Chital Nilgai, etc, are found in the forest area. The major birds found in the region are crow, sparrow, parakeet, fly weaver bird, swallow, wood-piker, cuckoo, Kingfisher, swift, owl, vulture, dove etc. (Reference : Merh S. S., "Geology of Gujarat").

2.8 Check Dams in Machhan River Basin

Efforts of harnessing water started long back since 1974 when Government constructed check dam at Sutharvasa under small irrigation scheme. In 1979 a medium irrigation scheme development project was taken up and an earthen and masonry dam was constructed on river Machhan by the Government of Gujarat near village Nansalai in Zalod Taluka. The scheme started functioning and irrigation started in the command area in 1985-86.

After Machhan Nala Irrigation project number of check dams was constructed by government but more systematic approach can be considered as efforts made by a NGO named N.M.Sadguru Water & Development Foundation. They started in 1990 at Rajudia and constructed 10 check dams in series on river Machhan and five check dams on its tributaries.

2.9 Check Dams on Machhan River

Location of check dams in the direction of river flow is mentioned in Table 2.3 and also shown in Fig.2.4. In general check dams on Machhan River can be broadly divided in to two classes:

2.9.1 Check Dams on U/S of Machhannala Irrigation Scheme

1. Kachumber Falia Check Dam
2. Wankol Check Dam
3. Simaliya Check Dam

2.9.2 Check Dams on D/S of Machhannala Irrigation Scheme:

1. Therka Check Dam
2. Kharsana Check Dam
3. Bambela Check Dam
4. Mahudi Check Dam
5. Rajudia Check Dam
6. Kheda Ambazaran Check Dam
7. Thunthi Kankasiya Check Dam

Table 2.2 gives location details of check dams on Machhan River.

Table – 2.2 Locations of Check Dams on Machhan River

Sr. No.	Check Dam Name	Year of Const.	Latitude	Longitude
1	Kachumber	1995	22°58'39"	74°08'03"
2	Wankol	1996	22°59'08"	74°07'56"
3	Simaliya	1998	22°59'52"	74°08'14"
4	Therka	1997	23°05'10"	74°11'37"
5	Kharsana	1999	23°08'29"	74°11'44"
6	Bambela	1996	23°09'06"	74°08'03"
7	Mahudi	1993	23°09'56"	74°12'10"
8	Rajudia	1990	23°10'08"	74°12'48"
9	Kheda Ambazaran	1999	23°10'05"	74°13'32"
10	Thunthi Kankasiya	1994	23°10'27"	74°13'58"

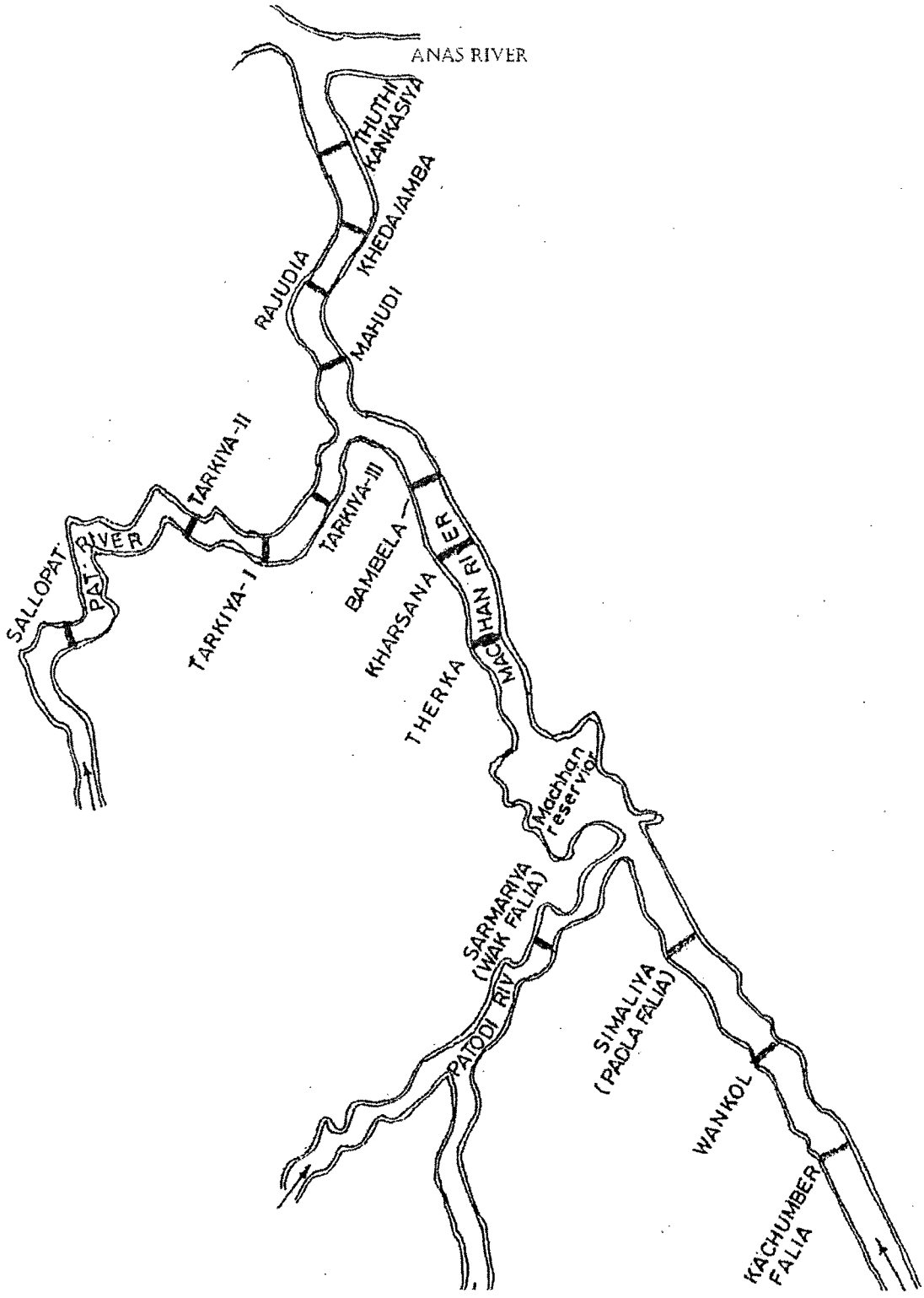


Figure 2.4: Check Dams on River Machhan