UWR Rainwater Offset Unit Standard

(UWR RoU Standard)

Concept & Design: Universal Water Registry

www.uwaterregistry.io

Project Name: Rainwater Harvesting & Bundled Check Dam Initiative – Gir Ganga Parivar Trust Project, Gujarat, India

UWR RoU Scope: RoU Scope 2
1st Monitoring Period: 03/03/2022-31/12/2024 (02 Years, 10 Months)
RoU Crediting Period: 2022-2024
UNDP Human Development Indicator: 0.633 (India)
National Water Security Index: 2 (India)

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A.1 Location of Project Activity

Project Proponent	Gir Ganga Parivar Trust
State	Gujarat
District	Rajkot, Bhavnagar
Block Basin/Sub Basin/Watershed	Shetrunji, Aji, Machu, Bhadar
Lat. & Longitude	**Location** / **Co-ordinates** Todi — 21°36'41"N 71°52'08"E Paddhari — 22°26'08"N 70°36'17"E Kagdadi — 22°28'08"N 70°46'46"E Vajdi Vad — 22°15'26"N 70°41'31"E Pambhar Intala — 22°17'01"N 70°37'02"E Jetakuba — 22°07'43"N 70°35'40"E Rajkot — 22°18'38"N 70°48'26"E
Area Extent	Groundwater Surface

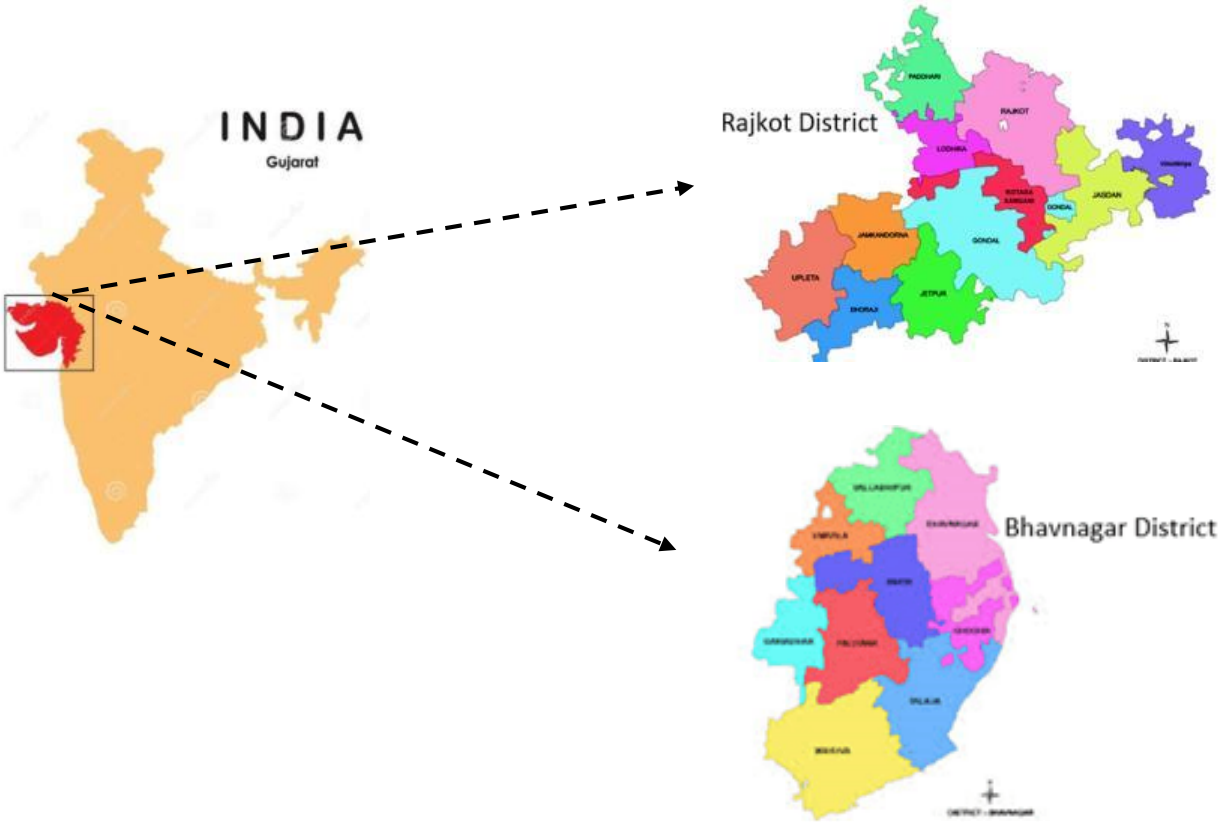

Figure 1: Project Location a) Rajkot b) Bhavnagar

A.2. Project owner information, key roles and responsibilities

The Gir Ganga Parivar Trust, project proponent (PP) is committed to the restoration and maintenance of check dams. As the PP, the trust ensures the successful operation and maintenance of these check dams, which are designed to capture and store rainwater runoff during the monsoon season. This stored water is used for irrigation, livestock, and daily needs in the region. The trust is responsible for maintaining the catchment areas of these check dams, ensuring that the rainwater flows smoothly into the dams, preventing wastage, and facilitating the efficient use of water throughout the year.

The current project specifically involves check dams in villages such as Jetukba, Vajdi Vad, and Pambhar Itada in Lodhika Taluka; Kagdadi in Tankara Taluka, Paddhari Taluka and Rajkot district and Todi village of Sihor Taluka of Bhavnagar district.

Details of the check dams are provided in the Table 1

Table 1: Location of the check dams

Sr. No.	Location	Co-ordinates	Commissioning Date
1	Jetukuba, Lodhika	22.119498 - 70.577236	06-04-2022
2	Jetukuba, Lodhika	22.129938 - 70.584320	20-06-2022
3	Jetukuba, Lodhika	22.119498 - 70.577236	28-06-2022
4	Jetukuba, Lodhika	22.132350 - 70.604269	28-06-2022
5	Jetukuba, Lodhika	22.132238 - 70.577172	29-06-2022
6	Jetukuba, Lodhika	22.130283 - 70.601070	20-07-2022
7	Jetukuba, Lodhika	22.119218 - 70.578256	20-07-2022
8	Jetukuba, Lodhika	22.129248 - 70.599208	20-07-2022

9	Jetukuba, Lodhika	22.128832 - 70.598593	22-07-2022
10	Jetukuba, Lodhika	22.128470 - 70.579767	05-05-2023
11	Jetukuba, Lodhika	22.125823 - 70.586048	05-07-2023
12	Kagdadi	22.473321 - 70.779743	09-01-2022
13	Kagdadi	22.498727 - 70.776495	09-01-2022
14	Kagdadi	22.483719 - 70.790534	09-01-2022
15	Kagdadi	22.474524 - 70.781041	09-01-2022
16	Kagdadi	22.500338 - 70.776495	29-06-2022
17	Kagdadi	22.467306 - 70.773874	31-08-2022
18	Kagdadi	22.474103 - 70.786134	22-09-2022
19	Kagdadi	22.486261 - 70.782880	22-09-2022
20	Kagdadi	22.494913 - 70.763823	24-09-2022
21	Kagdadi	22.492503 - 70.764749	24-09-2022
22	Kagdadi	22.485055 - 70.783989	24-09-2022
23	Kagdadi	22.481695 - 70.776141	25-09-2022
24	Paddhari	22.437310 - 70.612099	03-05-2023
25	Pambhar Itada	22.268316 - 70.621293	03-03-2022
26	Pambhar Itada	22.268962 - 70.620953	03-03-2022
27	Pambhar Itada	22.268940 - 70.621044	03-03-2022
28	Pambhar Itada	22.270767 - 70.620157	03-03-2022
29	Pambhar Itada	22.270986 - 70.614937	03-03-2022
30	Pambhar Itada	22.269721 - 70.615511	03-03-2022
31	Pambhar Itada	22.272053 - 70.619929	05-03-2022
32	Pambhar Itada	22.273900 - 70.619144	05-03-2022
33	Pambhar Itada	22.276777 - 70.617083	05-05-2022
34	Pambhar Itada	22.277706 - 70.616406	05-05-2022
35	Pambhar Itada	22.279092 - 70.614789	05-05-2022
36	Pambhar Itada	22.275929 - 70.625577	05-05-2022
37	Rajkot	22.264506 - 70.742969	21-07-2023
38	Rajkot	22.262440 - 70.741651	21-07-2023
39	Rajkot	22.272531 - 70.731743	09-04-2024
40	Rajkot	22.285683 - 70.745357	13-04-2024
41	Rajkot	22.297329 - 70.749109	09-05-2024
42	Rajkot	22.266209 - 70.766648	09-06-2024
43	Rajkot	22.270493 - 70.743470	18-06-2024
44	Rajkot	22.266917 - 70.762311	22-06-2024

45	Rajkot	22.257331 - 70.744129	28-06-2024
46	Rajkot	22.261840 - 70.737272	06-07-2024
47	Rajkot	22.259962 - 70.743798	07-07-2024
48	Todi, Bhavnagar	21.610291 - 71.871058	07-01-2022
49	Todi, Bhavnagar	21.610972 - 71.870836	08-06-2022
50	Todi, Bhavnagar	21.611251 - 71.873709	08-06-2022
51	Todi, Bhavnagar	21.610220 - 71.871437	08-07-2022
52	Todi, Bhavnagar	21.609546 - 71.866252	08-08-2022
53	Todi, Bhavnagar	21.614122 - 71.875595	13-08-2022
54	Todi, Bhavnagar	21.613749 - 71.865874	15-08-2022
55	Todi, Bhavnagar	21.615513 - 71.865669	15-08-2022
56	Todi, Bhavnagar	21.606945 - 71.869386	20-08-2022
57	Todi, Bhavnagar	21.613057 - 71.873920	14-09-2022
58	Todi, Bhavnagar	21.612502 - 71.871500	15-09-2022
59	Todi, Bhavnagar	21.608074 - 71.865864	15-09-2022
60	Todi, Bhavnagar	21.602715 - 71.868848	20-09-2022
61	Todi, Bhavnagar	21.611027 - 71.873691	08-10-2022
62	Todi, Bhavnagar	21.615545 - 71.876455	09-10-2022
63	Todi, Bhavnagar	21.612453 - 71.865181	09-10-2022
64	Todi, Bhavnagar	21.612308 - 71.865313	09-10-2022
65	Todi, Bhavnagar	21.611490 - 71.876985	09-10-2022
66	Todi, Bhavnagar	21.608016 - 71.865865	08-11-2022
67	Todi, Bhavnagar	21.609781 - 71.866514	08-11-2022
68	Vajdi Vad	22.261989 - 70.695647	07-02-2022
69	Vajdi Vad	22.260216 - 70.685591	13-05-2022
70	Vajdi Vad	22.262946 - 70.700955	06-06-2022
71	Vajdi Vad	22.262614 - 70.696985	11-08-2022
72	Vajdi Vad	22.261739 - 70.693896	25-09-2022
73	Vajdi Vad	22.261559 - 70.692796	29-09-2022
74	Vajdi Vad	22.262217 - 70.694773	30-09-2022
75	Vajdi Vad	22.273813 - 70.697023	06-10-2022
76	Vajdi Vad	22.263093 - 70.696358	09-10-2022
77	Vajdi Vad	22.258439 - 70.701446	06-11-2022
78	Vajdi Vad	22.261456 - 70.690834	09-11-2022
79	Vajdi Vad	22.256506 - 70.696658	22-02-2023

80	Vajdi Vad	22.254280 - 70.697455	22-02-2023
81	Vajdi Vad	22.265511 - 70.693038	30-04-2023
82	Vajdi Vad	22.260694 - 70.688653	05-08-2023
83	Vajdi Vad	22.265579 - 70.694678	05-10-2023
84	Vajdi Vad	22.261923 - 70.686809	05-12-2023

A.2.1 Project RoU Scope

<table>
<tr><td>Project Name</td><td>Rainwater Harvesting & Bundled Check Dam Initiative – Gir Ganga Project, Gujarat, India</td></tr>
<tr><td>UWR Scope</td><td>RoU Scope 2: Measures for conservation and storage of excess surface water for future requirement</td></tr>
<tr><td>Date PCNMR Prepared</td><td>11/02/2025</td></tr>
<tr><td>Catchment Area</td><td>
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<tr><th colspan="3">Total Catchment Area (m^2)</th></tr>
<tr><td>Bhavnagar</td><td>Rajkot</td><td>Total</td></tr>
<tr><td>7090</td><td>272875.2</td><td>279965.2</td></tr>
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</td></tr>
<tr><td>Type of Construction</td><td>Concrete</td></tr>
<tr><td>Average Rainfall</td><td>Rajkot- 709.8mm
Bhavnagar- 598.4mm</td></tr>
<tr><td>Run Off Coefficient</td><td>0.3</td></tr>
<tr><td>Evaporation & Absorption losses</td><td>20%</td></tr>
<tr><td>Catchment Capacity</td><td>
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<tr><th colspan="3">Total Catchment Capacity (m^3)</th></tr>
<tr><td>Bhavnagar</td><td>Rajkot</td><td>Total</td></tr>
<tr><td>32563.6128</td><td>1064169.97</td><td>1096733.585</td></tr>
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<tr><td>RoU Crediting Period</td><td>2022-2024 (02 Years, 10 Months)</td></tr>
<tr><td>Total RoUs Generated For the Crediting Period</td><td>
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<tr><th rowspan="2">Year</th><th rowspan="2">Crediting Period (DD/MM/YYYY)</th><th>RoUs (1000 Litres)/Year</th></tr>
<tr><th>Total</th></tr>
<tr><td>2022</td><td>3/3/2022-31/12/2022</td><td>9004</td></tr>
<tr><td>2023</td><td>1/1/2023-31/12/2023</td><td>10943</td></tr>
<tr><td>2024</td><td>1/1/2024-31/12/2024</td><td>61422</td></tr>
<tr><td colspan="2">Total</td><td>81369</td></tr>
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A.3. Land use and Drainage Pattern

A.3.1 Urban and Rural Residential

A.3.1.1 Introduction

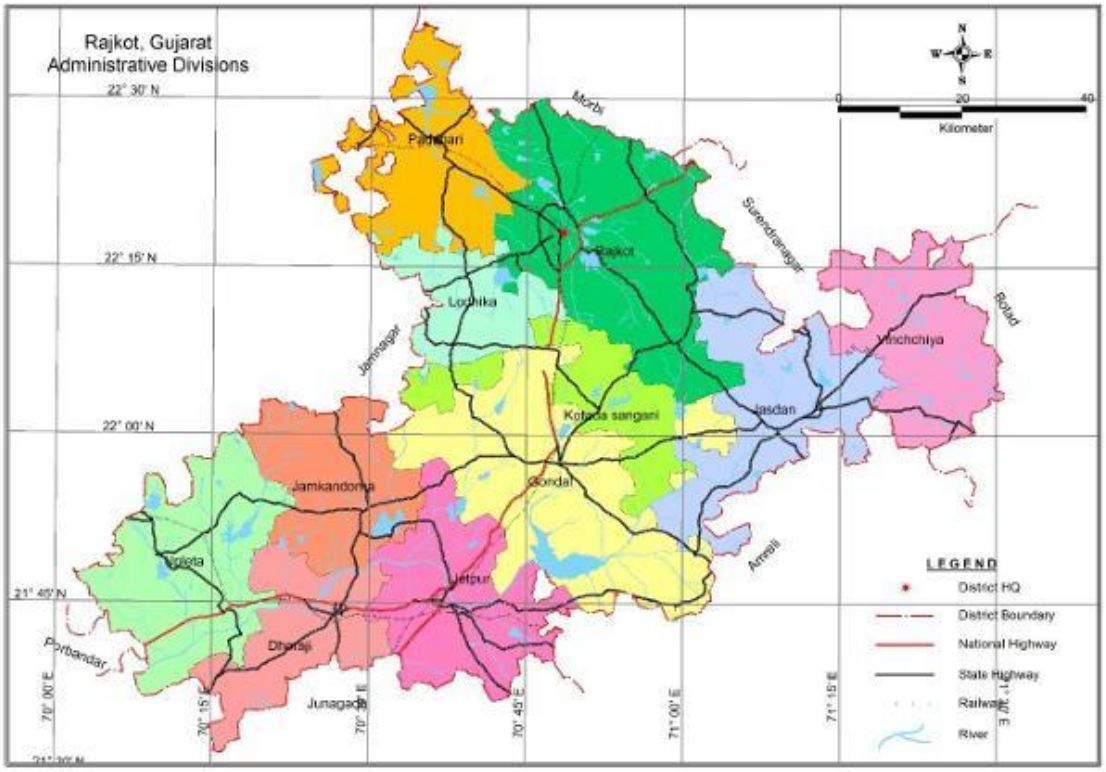

Figure 2: Map of Rajkot District

Rajkot district is located in Saurashtra region of Gujarat, spans 11,203 square kilometers and sits between latitudes 20°30' N and 23°12' N and longitudes 70°00' E and 71°45' E. The district is bordered by the Rann of Kachchh to the north, Surendranagar to the east, Jamnagar to the west, and Junagadh and Amreli to the south. The largest city in Saurashtra, Rajkot, serves as the administrative and industrial center of the district, situated along the Aji and Nyari rivers and covering 170 square kilometers. Rajkot is a prominent producer of cotton, oilseeds, spices, and fireclay. The district's economy is bolstered by agriculture, small-scale manufacturing, and heavy industries, making it a significant contributor to Gujarat's economy. Rajkot final Gujarat.pdf

Table 2: List of Taluka of Rajkot District

Sr No	Name of Taluka	Area (Sq.Km)	No of Villages
1	Dhoraji	484.94	30
2	Gondal	1193.62	81
3	Jamkandorna	560.29	50
4	Jasdan	833.42	53
5	Jetpur	627.58	47
6	Kotada sangani	447	42
7	Lodhika	373.23	38
8	Paddhari	599.33	58
9	Rajkot	1004.88	96
10	Upleta	839.24	51
11	Vinchchiya	510.3	52
	Total	**7473.83**	**598**

Figure 3: Bhavnagar District

Bhavnagar district, situated in the southern part of Gujarat's Saurashtra region, spans an area of 9,980.9 square kilometers. Established in 1723 AD by Bhavsinhji Gohil, it is a significant hub for maritime trade due to its strategic location near the Gulf of Cambay. The district's administrative headquarters is Bhavnagar city, positioned at 21.77°N and 72.15°E with an average elevation of 24 meters.

Bhavnagar is bordered by Ahmedabad and Surendranagar to the north, Rajkot and Amreli to the west, and the Arabian Sea and the Gulf of Cambay to the south and east. As per the 2011 Census, the district's population stands at 2.88 million, reflecting a literacy rate of 86.15% for males and 66.92% for females. Known for its coastal significance, Bhavnagar has a rich history of trade and development, making it a vital part of Gujarat's economic and cultural landscape.

https://cdn.s3waas.gov.in/s3ccb0989662211f61edae2e26d58ea92f/uploads/2018/09/2018092869.pdf

A.3.1.2. Physiography

Rajkot district, spanning 11,203 square kilometers in the central Saurashtra peninsula, features diverse terrain, with elevations ranging from sea level to 304 meters at Bhadala. The northern region, particularly Malia taluka, consists of flat alluvial plains bordering the Rann of Kachchh, while the southern areas like Morbi and Wankaner talukas are characterized by rugged terrain formed by Deccan Trap basalt and sandstone ridges, including the prominent Sardhar Dyke along the Bhadar River. The district is divided into three primary physiographic regions: the floodplains of the Bhadar and Aji Rivers, the Rajkot Stony-Waste Land, and Vinchhiya Upland. Soils are mainly clayey loam to clay, supporting diverse agriculture and industries across the district. The area features rocky soils in parts of Lodhika and Rajkot talukas, contributing to its varied topography.

Rajkot final Gujarat.pdf, https://seiaa.gujarat.gov.in/DSR%20Rajkot%20District.pdf

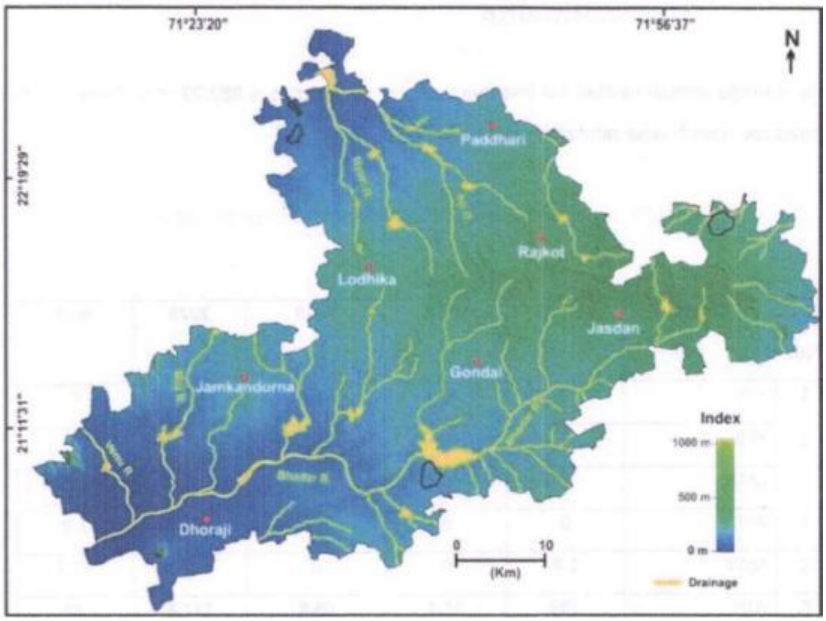

Figure 4: Physiography Plan of Rajkot District

https://seiaa.gujarat.gov.in/DSR%20Rajkot%20District.pdf

Bhavnagar district's physiography is marked by diverse features, ranging from coastal marshes and sandy areas near the Gulf of Cambay (Khambhat) to hilly terrains in the south and northwest. The district encompasses two primary physical regions: the coastal plains and the inland plains. The coastal plains, scattered with rocks, creeks, and hillocks, feature sandy marshlands that stretch along the Gulf of Cambay. In contrast, the inland plains vary from flat areas to undulating terrains interrupted by hills, such as those near Charnardi (109 m) and Shogadh (86 m). The hilly regions, including Palitana and Sihor in the south

and Botad and Gadhada in the northwest, are characterized by elevations ranging from 100 to 501 meters above mean sea level. The Shetruji Hills, located southwest of Palitana, reach the highest elevation in the district at 501 meters and run parallel to the coast in a southwest-northeast direction. The regional slope of the district generally inclines towards the southeast, with rivers such as the Shetrunji, Kalubhar, Ghelo, and Vagad flowing in this direction. However, in Mahuva taluka, streams flow southward into the Arabian Sea, reflecting the southern slope of the terrain. This diverse topography, comprising coastal and inland plains interspersed with hill ranges, defines the district's unique ecological and geographical significance.

DSR Bhavnagar District.pdf,https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

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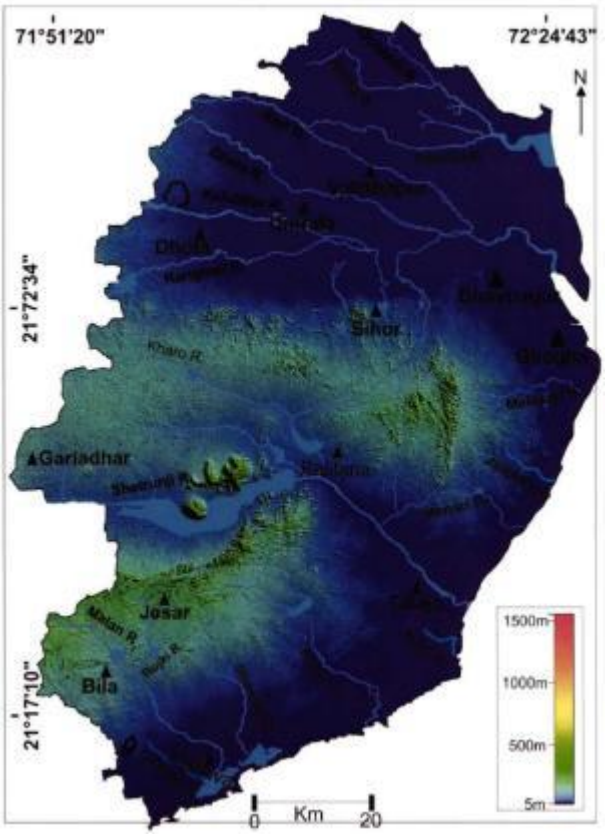


Figure 5: Physiographic Plan of Bhavnagar District

A.3.1.3. Geology

Rajkot district, located in the central part of the Saurashtra peninsula, exhibits a diverse topography shaped by volcanic and sedimentary processes. The northern region, bordering the Rann of Kachchh, features rugged terrain predominantly formed by Deccan Trap basalt. This volcanic formation is characterized by intersecting dykes and ridges, with some reaching elevations of up to 300 meters,

including the Sardhar Dyke along the Bhadar River. The highest point in the district, near Bhadala in the east-central part, rises to 304 meters.

Soils in Rajkot are mainly clayey loam to clay, contributing to the region's agricultural and ecological diversity. In the central part of the district, including Paddhari, Lodhika, and Rajkot, the soils are moderately deep with Electrical Conductivity (EC) below 1.0 mmhos/cm and Cation Exchange Capacity (CEC) ranging from 40 to 60 me/100 gm. The southern region, including Jetpur, Dhoraji, Upleta, and Gondal, also features clayey soils of similar depth and chemical properties. This variation in soil types, along with the underlying geology, supports the agricultural and industrial activities that characterize Rajkot.

Table 3: Geological Succession of Rajkot District

https://seiaa.gujarat.gov.in/DSR%20Rajkot%20District.pdf

Age	Group	Formation	Lithology
Holocene to recent	Quaternary Sediment		Undifferentiated alluvium, Sand dunes, Run Clay, Mud and Soil
Pleistocene	Porbandar Group	Miliolite Formation	Calcarenite, Coral and Shell, Limestone, Mari and Conglomerate
------Unconformity------			
Upper Cretaceous to Eocene	Deccan Volcanic	Acidic Deccan Volcanic	Acidic (Rhyolite) Flow, Dyke of Rhyolite,
		Intertrappean Deccan Volcanic	Cherty Limestone and Porcellanite (Intra-trappean)
		Deccan Trap	Basaltic Flow, Basaltic and Doleritic dyke

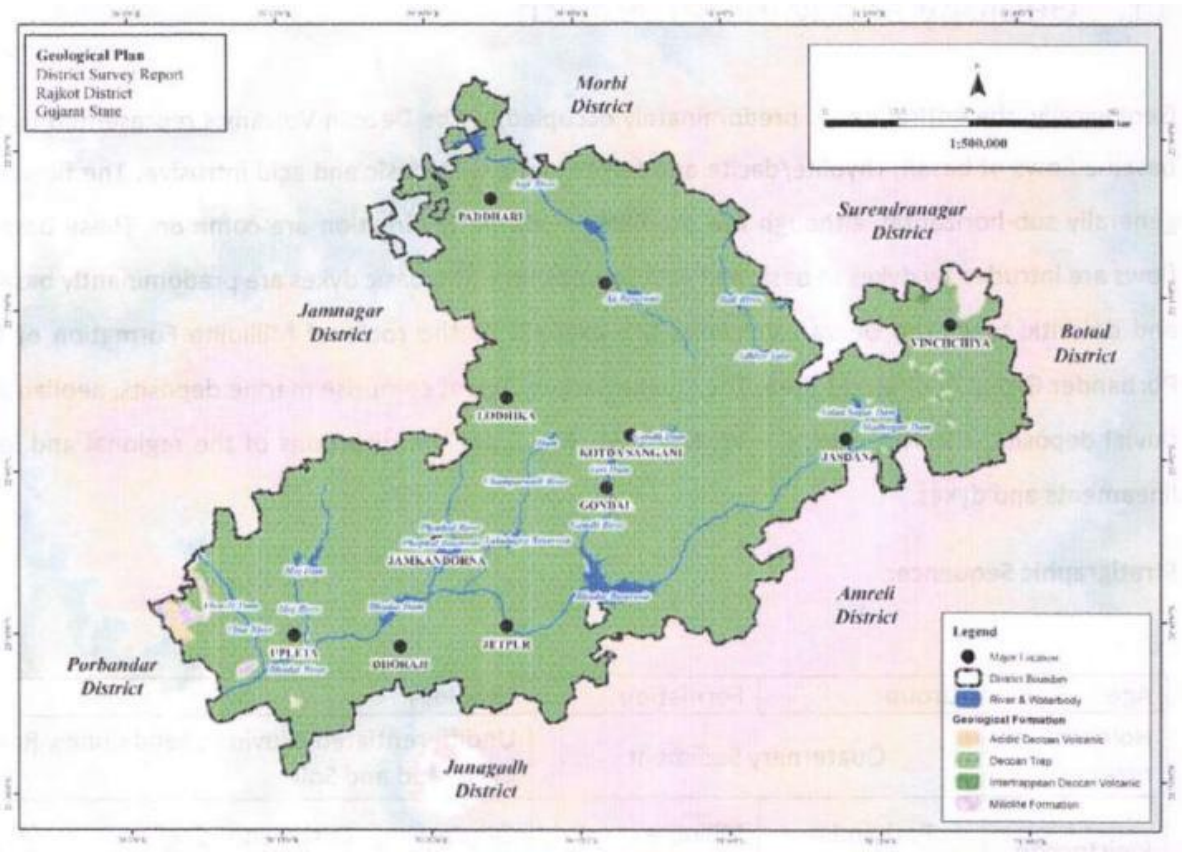


Figure 6: Geological Map of Rajkot District

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Rajkot.pdf

https://smartcityrajkot.in/Rajkot)

https://pmksy.gov.in/mis/Uploads/2016/20160816051209369-1.pdf

The geology of Bhavnagar district in Gujarat is marked by a diverse range of rock formations and deposits. The region is primarily composed of sedimentary rocks, including significant layers of limestone, marl, and conglomerates. In the eastern part of the district, Deccan Trap Basalts dominate, forming part of the extensive Deccan Plateau that stretches across much of western India. Additionally, Bhavnagar is known for its lignite deposits, particularly in areas like Khadsaliya, where lignite coal is extracted from Miocene and Eocene formations, which consist of clays, sandstones, and impure limestone.

The soils in Bhavnagar are directly influenced by the district's underlying geology. Medium black soils, derived from basalt and other volcanic rock formations, are widespread across the district. These soils are rich in lime, magnesium, and alumina but lack sufficient phosphorus, nitrogen, and organic matter.

Despite these deficiencies, they are highly suitable for agriculture due to their moisture retention capacity. Along the Shetrunji River, in areas like Gariyadhar and Palitana talukas, alluvial soils are found, though their productivity is limited due to high salinity. Alkaline soils, commonly present in Gariyadhar taluka, vary in productivity and are caused by factors such as poor drainage and groundwater evaporation, which leads to salt accumulation.

In summary, the soils of Bhavnagar district can be categorized into three types:

1. **Medium Black Soils**: These are the most widespread, found in all talukas, and are suitable for agriculture due to their moisture retention properties, although they are poor in nutrients like phosphorus, nitrogen, and organic matter.
2. **Alluvial Soils**: Found along the Shetrunjhi River, these soils are less productive because of salinity.
3. **Alkaline Soils**: Located in parts of Gariyadhar taluka, these soils vary in their productivity, with some being suitable for agriculture and others less so due to salinity and poor drainage conditions.

Table 4: Geological Succession of Bhavnagar District

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

Geological Succession

Era	Age	Formation	Lithology
Quaternary	Recent to Sub-Recent	Surface Soil/ Alluvium	Thick beds of calcareous clay, intercalated with layers of trap sand.
--Unconformity--			
Tertiary	Lower Eocene to Upper Cretaceous	Deccan trap	Basalt as stratified lava flows comprising amygdaloidal basalt, fine grained porphyritic basalt and basaltic/dolerite dykes.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

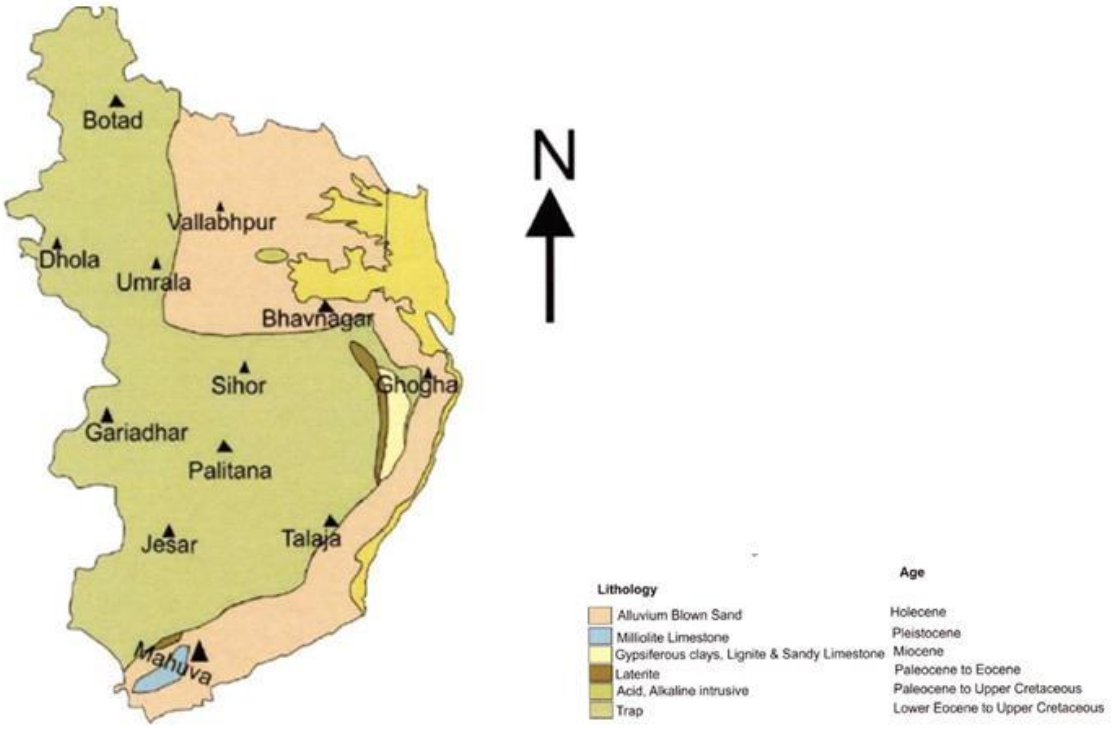


Figure 7: Geological Map of Bhavnagar District DSR Bhavnagar District.pdf

A 3.1.3 Hydrogeology

The hydrogeology of **Rajkot district** is shaped by three key geological formations: Dhrangadhra Sandstone**,** Deccan Trap basalt and Alluvium. The Dhrangadhra Sandstone, located in the northeastern parts of Wankaner and Morvi talukas, has poor permeability but yields groundwater through fractures and bedding planes, providing well yields between 30 and 120 m^3/day. The Deccan Trap basalt, covering most of the district, forms a low-yield aquifer due to its compactness, although weathered zones and fractures improve its potential, with groundwater yields ranging from 20 to 100 m^3/day. In the northern parts, alluvium forms poor aquifers with limited development due to poor water quality. Groundwater levels across Rajkot show variability, with pre-monsoon depths ranging from 0.78 to 22.45 meters below ground level.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Rajkot.pdf

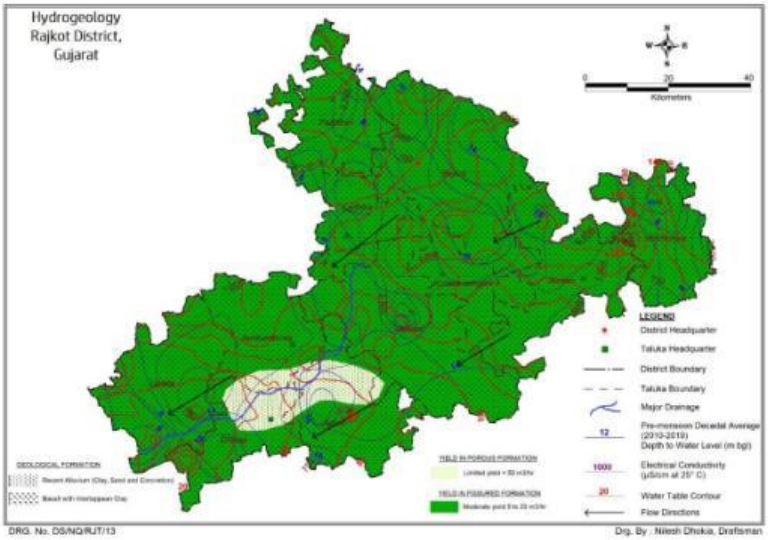


Figure 8: Hydrogeological Map of Rajkot

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Rajkot.pdf

The hydrogeology of Bhavnagar district is shaped by diverse geological formations, with groundwater occurring primarily under water table and semi-confined conditions. The Deccan Trap and Quaternary formations form the main aquifers, influencing the availability and movement of groundwater. In the eastern part of the district, around Panvi, the Quaternary formations, consisting of clays, marl, and sand gravel, are shallow to moderately thick and contribute to groundwater storage under unconfined conditions. These formations are highly affected by both primary and secondary porosity, which control groundwater movement. Dug and dug-cum-bore wells are commonly used for groundwater extraction, with yields ranging from 170 m^3/day to 800 m^3/day in these formations.

The Deccan Trap, covering a significant portion of the district, forms a major aquifer system but is generally considered a poor aquifer due to compactness and low primary porosity. However, the weathered upper layers, which can reach up to 20 meters in thickness, act as productive aquifers. Secondary porosity, developed through tectonic activities like fractures and shear zones, further enhances groundwater storage at certain depths. Wells in these basaltic formations, such as dug wells and dug-cum-bore wells, typically yield between 100 m^3/day to 500 m^3/day, although this can increase to 1,000 m^3/day in areas with vesicular or amygdaloidal basalt layers. Groundwater in the alluvial deposits, particularly in the central part of Bhavnagar, is a significant aquifer with wells yielding up to 820 m^3/day. Horizontal bores are often drilled in wells to improve water extraction, particularly in the alluvial zones.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

A 3.2 Land Use

Rajkot district predominantly features an agricultural landscape, with approximately 60-65% of its total area dedicated to crop cultivation, which includes both irrigated and rainfed farming. The urban and built-up areas around Rajkot city have expanded due to industrialization and urban growth, leading to a reduction in natural vegetation and barren land in certain areas. Forest cover in the district comprises 3% of the total area.

Water bodies primarily serve irrigation and drinking water needs, supporting the district's agricultural activities. Rajkot district has a total geographical area (TGA) of 768,989 hectares, with the largest block, Gondal, accounting for 119,362 hectares (approximately 15.5% of the district's TGA). The net cropped area (NCA) of the district is 532,582 hectares, with Gondal block contributing 16.83% (89,620 hectares) and Rajkot block contributing 11.84% (63,050 hectares) of this area. Additionally, 2% of the district's TGA, or 16,900 hectares, is under forest cover, while 8.7% of the total area, or 63,545 hectares, is categorized as wasteland

https://stats.iop.org/article/10.1088/1755-1315/1387/1/012021/pdf,
https://pmksy.gov.in/mis/Uploads/2016/20160816051209369-1.pdf

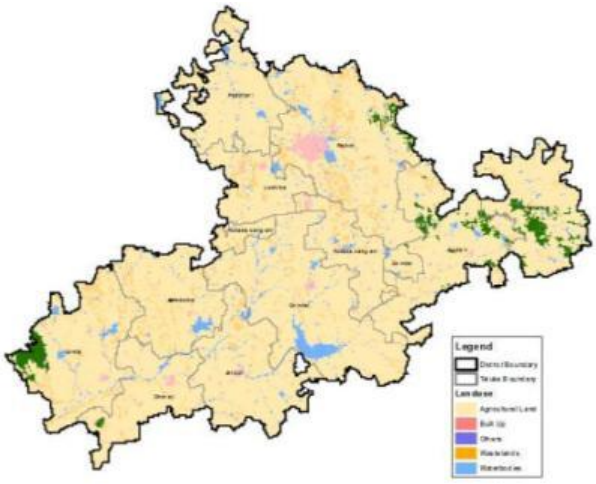


Figure 9: Land Use Classification of Rajkot District

Table 5: Land Use Pattern of Rajkot District

	Area (ha)
Total Area	7,53,752
Forest land	16,228
Area not available for Cultivation	63,956
Permanent Pastures and Grazing Land	62,689
Cultivable Wasteland	7384
Land under Misc. tree crops and groves	-
Current Fallow	22,855
Other Fallow	-
Net Sown Area	5,26,112
Total or Gross Cropped Area	5,56,067
Area Cultivated more than once	29,955
Mining Area	615.0443

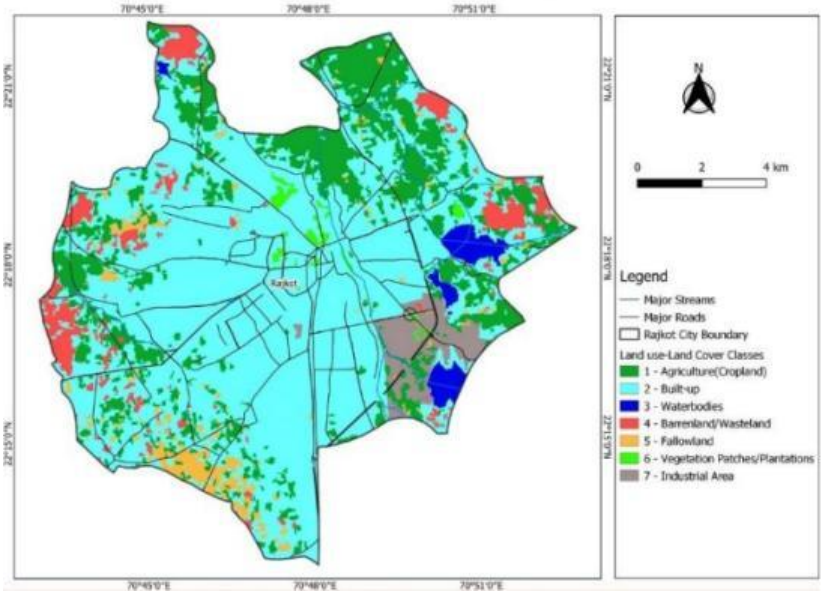


Figure 10: Land Use map of Rajkot

https://www.bhu.ac.in/research_pub/jsr/Volumes/JSR_66_03_2022/6.pdf

The land use pattern of Bhavnagar district in Gujarat reflects its diverse agricultural activities, with a notable portion of the district dedicated to crop cultivation. Agriculture is the dominant land use, occupying about 70-80% of the district's land area. The primary crops grown include cotton, groundnut, and various cereals and pulses, with a significant area also dedicated to horticultural crops. In addition to agriculture, the district also sees land use for residential, commercial, and industrial purposes, particularly in urban areas like Bhavnagar city.

The remaining land is utilized for forests, wastelands, and water bodies. While the district does not have extensive forest cover, the available forest areas contribute to local biodiversity and ecological balance. The land use distribution is also influenced by the region's climate and topography, which supports various cropping systems, from rainfed to irrigated agriculture, contributing significantly to the economy of the region.

https://sciresol.s3.us-east-2.amazonaws.com/srs-j/bu_journals/GA/pdf/Volume-9/Issue-1/Geographical_Analysis_June_2020_10.pdf

Table 6: Land Use Pattern of Bhavnagar District

Sr No	Land Use Classification	Area in Hectare
1	Geographic Area	857945
2	Forest Area	26924
3	Barren and uncultarabale land	98557
4	Land put to nonagricultural uses	59782
5	Permanent pasture and other grazing land	61188
6	Culturable waste	601394
7	Current fallows	61940
8	Net sown area	548535
9	Area sown more than once	33466
10	Gross cropped area	582001

A.3.3 Drainage

Rajkot district's drainage system is defined by three major rivers—Bhadar, Machhu, and Aji—along with their tributaries. The region exhibits a dendritic drainage pattern shaped by its undulating terrain, with elevations ranging from sea level to 304 meters. The rivers predominantly flow westward and northward, emptying into the Arabian Sea and the Little Rann of Kutch.

Seasonal rainfall and localized radial drainage patterns in the hilly areas influence the hydrology, making the rivers a vital resource for agriculture, drinking water, and groundwater recharge. Tributaries such as Gondali, Chapparwadi, and Phopal contribute to the complexity and utility of the system, while reservoirs

like Machhu I and II and the Aji dams regulate water flow, ensuring year-round availability despite the semi-arid climate.

https://www.cgwb.gov.in/old_website/AQM/NAQUIM_REPORT/Gujarat/Rajkot%20final%20Gujarat.pdf

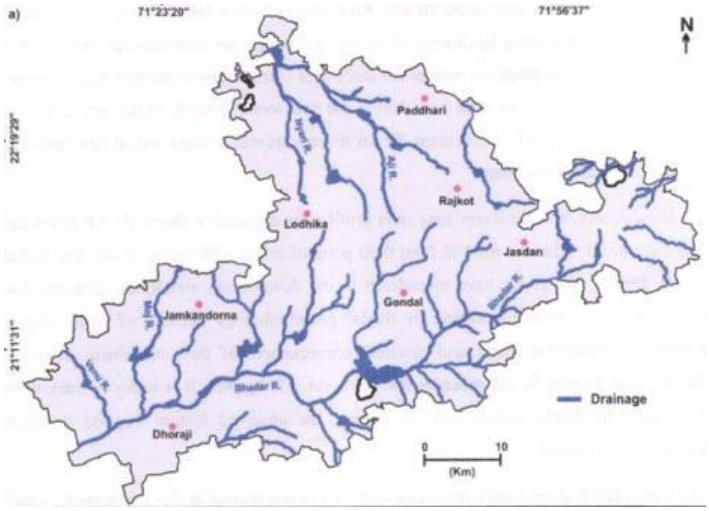


Figure 11: Drainage System of Rajkot

https://seiaa.gujarat.gov.in/DSR%20Rajkot%20District.pdf

The drainage system of Bhavnagar district is dominated by the Shetrunji River, which significantly influences the region's hydrology. Originating in the Dundhi hills of the Gir forest in Junagadh, the Shetrunji River enters Bhavnagar district near Karjala and flows predominantly southeastward. Covering a length of approximately 98 km within the district, it traverses Gariadhar, Palitana, and Talaja talukas before debouching into the Gulf of Cambay near Sultanpur. The river's southeasterly flow aligns with the district's regional slope and physiographic features. Most other streams in the district are ephemeral, flowing in a southeasterly direction, except in Mahuva taluka, where they flow southward into the Arabian Sea. The Shetrunji River serves as the primary drainage system, shaping the ecological and agricultural landscape of Bhavnagar district.

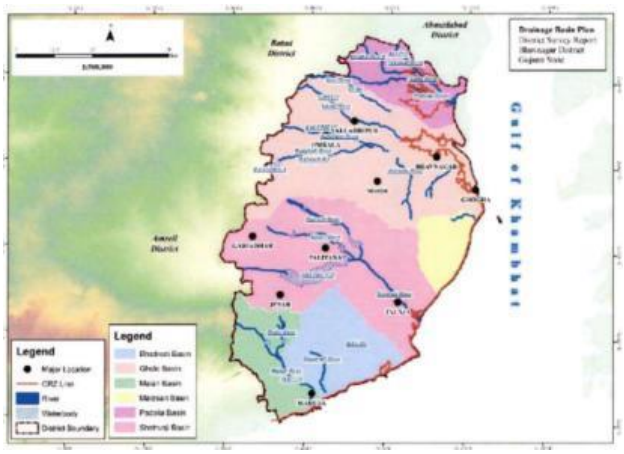


Figure 12: Drainage System of Bhavnagar

Table 7: River Drainage and Catchment Details

Sr. No.	District	River	Drainage Area (km^2)	% of Total Area	Length (km)	Catchment Area (km^2)
1	Rajkot	Bhadar	4902.67	69.11	198	7094
2		Machhuu	1924	76.51	141.75	2515.00
3		Aji	2130	30.03	102	142
4	Bhavnagar	Shetrunji	2492.88	45.21	182	5514

A.3.4 River Basin

Rajkot district lies within the Saurashtra region of Gujarat and is primarily drained by three river basins: **Bhadar, Machhu, and Aji**. These basins contribute significantly to the water systems of the semi-arid region, influencing its agriculture and ecosystem.

The **Bhadar River Basin**, the largest in Rajkot, covers an area of 7,094 square kilometers, draining nearly one-seventh of the Saurashtra peninsula. The river originates at Vaddi (261 m above sea level) and flows through Rajkot, Junagadh, and other districts, finally discharging into the Arabian Sea. The basin features hilly terrain (706 sq. km) and plains, with an average annual rainfall of 625 mm. Tributaries such as Gondali, Chapparwadi, Phopal, Moj, and Venu bolster its water flow, supporting agriculture and groundwater recharge.

https://guj-nwrws.gujarat.gov.in/downloads/basin_description.pdf

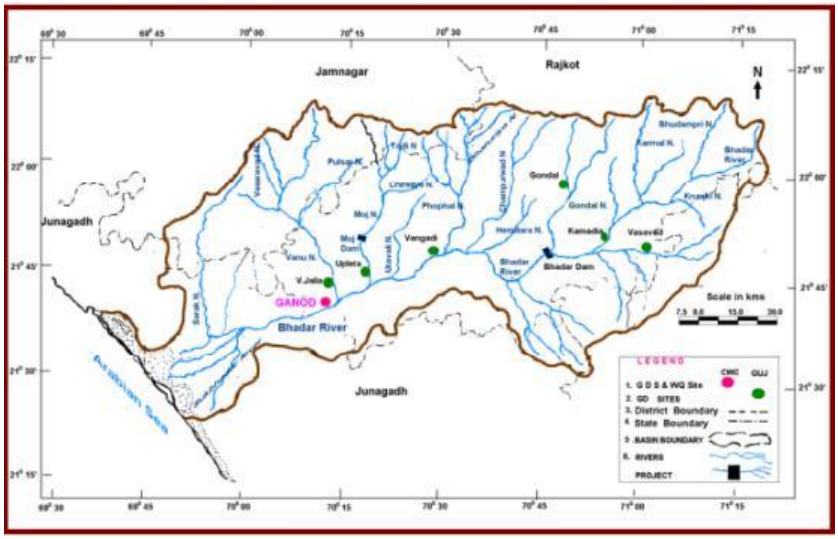


Figure 13: River Basin of Bhadar River

https://guj-nwrws.gujarat.gov.in/downloads/basin_description.pdf

The **Machhu River Basin**, spanning 2,515 square kilometers, originates in Jasdan's hill ranges. It flows 141.75 kilometers northward, draining into the Little Rann of Kutch. The river system includes tributaries like Beti, Maha, Machhori, and Asoi, which enhance its hydrological capacity. Machhu I and II irrigation schemes provide substantial storage and play a crucial role in water supply and agricultural sustainability across the district. https://guj-nwrws.gujarat.gov.in/downloads/basin_description.pdf

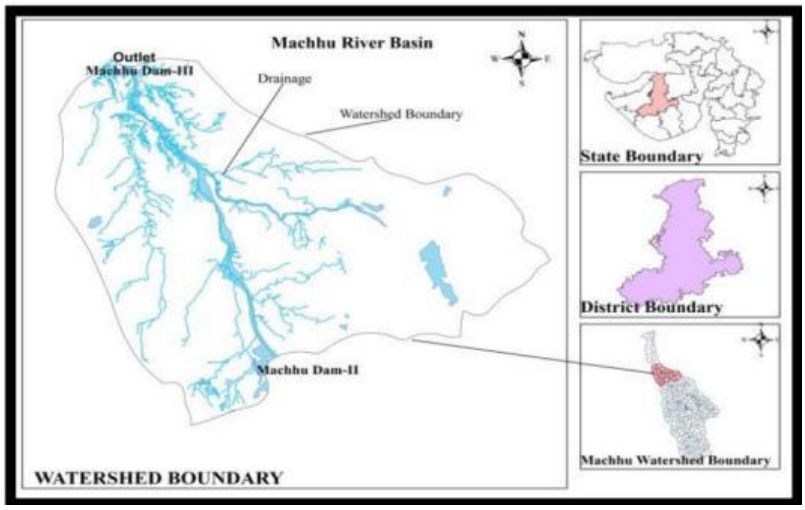


Figure 14: River Basin of Machhu River

https://www.cgwb.gov.in/old_website/AQM/NAQUIM_REPORT/Gujarat/Rajkot%20final%20Gujarat.pdf

The **Aji River Basin** supports the northern regions of Rajkot. Originating from the hills of Sardhar and Lodhika, the river flows through several talukas before emptying into the Arabian Sea. Four dams on the Aji River, including Aji I, ensure adequate water for irrigation, drinking, and industrial use in Rajkot city and its surroundings. The basin's undulating terrain and floodplains sustain the local ecosystem and agricultural activities.

https://www.webindia123.com/city/gujarat/rajkot/destinations/dams-lakes/ajiriveranddam.htm

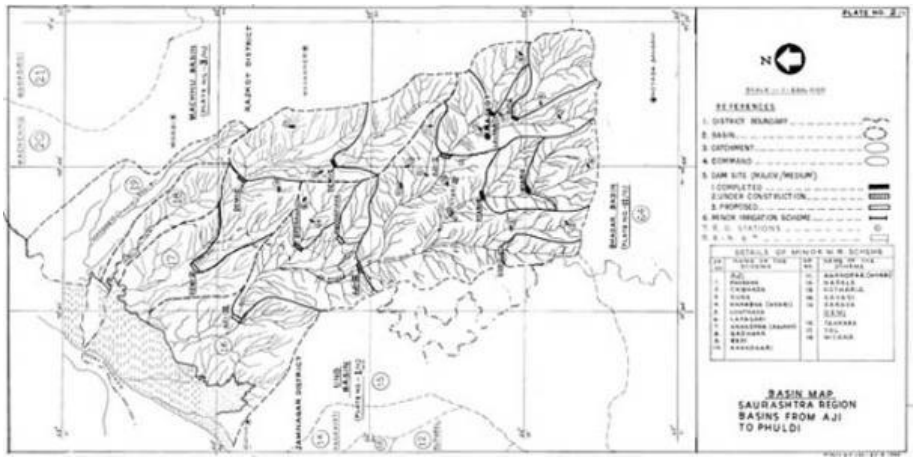


Figure 15: River Basin map of Aji River

https://guj-nwrws.gujarat.gov.in/showpage.aspx?contentid=1940&lang=English

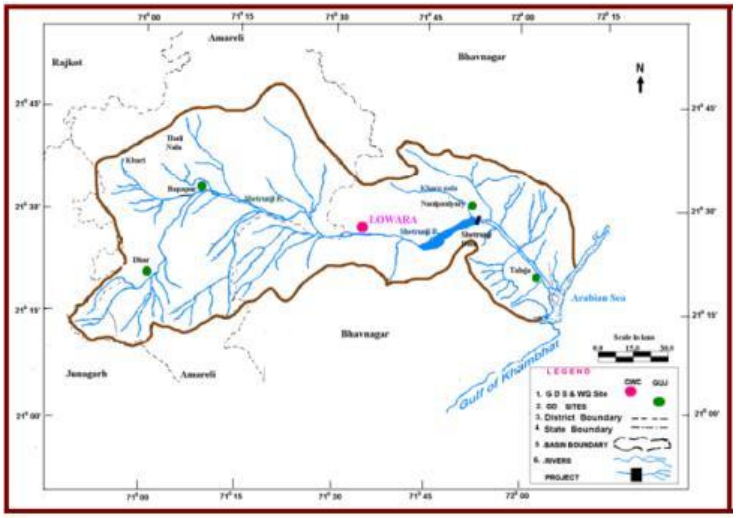


Figure 16: River Basin of Shetrunji River

https://guj-nwrws.gujarat.gov.in/downloads/basin_description.pdf

The **Shetrunji Basin**, one of the major river basins of Saurashtra, is the easternmost basin in the region, located between 21°00' to 21°47' North latitude and 70°50' to 72°10' East longitude. The Shetrunji River originates at the Chachai hills in the Gir forest of Junagadh district at an elevation of 380 meters above mean sea level. Flowing predominantly eastward, the river eventually meets the Gulf of Khambhat near Santhrampur port.

The basin covers a total area of 5,514 square kilometers, with more than 50% situated in Amreli district and the remaining in Bhavnagar and parts of Junagadh district. The Shetrunji River supports the fertility and agriculture of these regions, playing a vital role in the ecological and economic framework of Saurashtra. Its course and drainage patterns make it a significant water resource in the eastern Saurashtra landscape.

A.3.5 Description of River System

The river system of Rajkot district is characterized by three primary rivers Bhadar, Machhu, and Aji along with several tributaries that together shape the hydrology and ecology of the region. These rivers originate from hilly terrains and flow through varied topographies, including plains and agricultural lands, before joining larger water systems or seas.

The **Bhadar River** is the largest river in the district, originating at an elevation of 261 meters above sea level from the Vindhya uplands near Vaddi village. Spanning a length of 198 km, it flows southwest through key regions like Jasdan and Jetpur, ultimately emptying into the Arabian Sea at Navibandar in Porbandar. The river's extensive basin drains approximately 7,094 square kilometers, equivalent to about one-seventh of Saurashtra's land area. Its major tributaries include Gondali, Chapparwadi, Phopal, Moj, and Venu, with most located on the left bank. These tributaries enhance the agricultural fertility of the basin and support vital irrigation and water needs. The Bhadar is also home to the Bhadar Irrigation Scheme, with significant storage capacity that sustains water resources in the area.

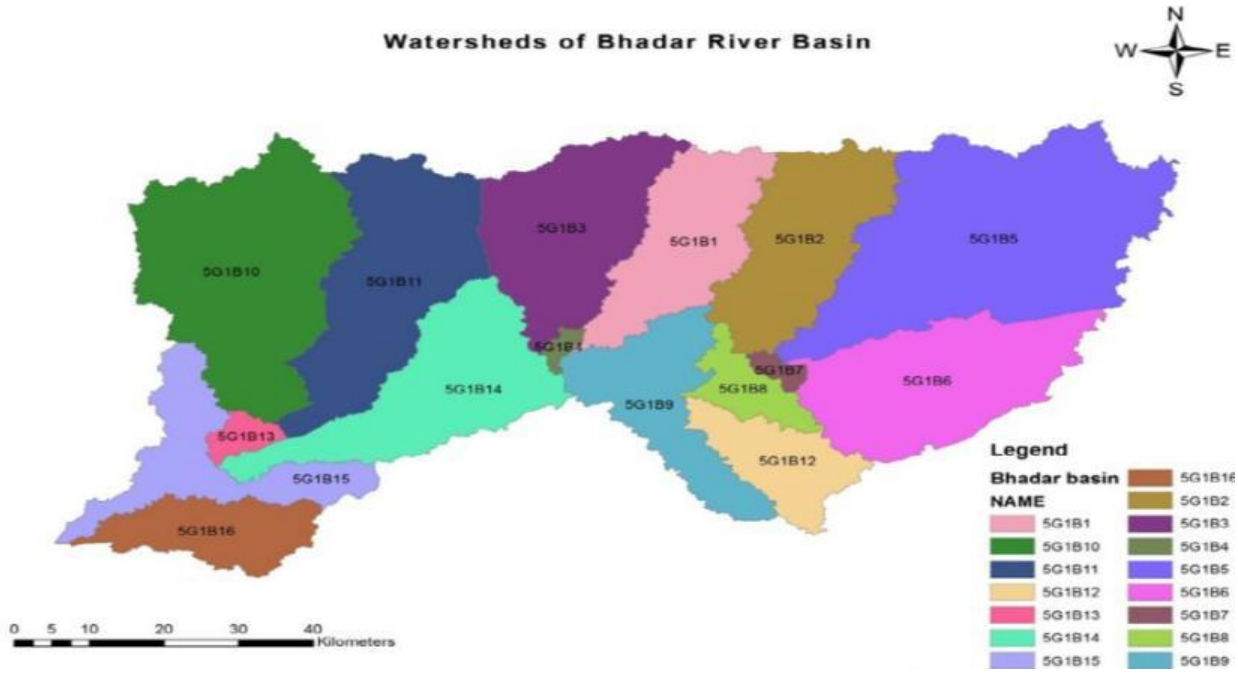


Figure 17: Watershed map of Bhadar river basin

https://journals.ansfoundation.org/index.php/jans/article/view/2032,https://ijsrd.com/articles/IJSRDV3I31070.pdf

The **Machhu River** originates from the hills near Khokhara village in Chotila taluka, Surendranagar district, at an elevation of 220 meters. Flowing for 141.75 km, it primarily traverses Rajkot and Surendranagar districts before draining into the Little Rann of Kutch. The Machhu basin covers 2,515 square kilometers, with its catchment area divided between hilly (52%) and plain (48%) regions. Major tributaries such as Beti, Asoi, Machhori, and Maha significantly contribute to its water volume, with Maha being the principal tributary. The river supports two key irrigation projects: Machhu I and II, which serve Wankaner and Morbi talukas, ensuring a steady water supply for agriculture and local communities.

The **Aji River** originates from the Sardhar and Lodhika hills and flows northward before joining the Arabian Sea. Stretching approximately 102 km, it plays a critical role in sustaining the semi-arid region's water demands. Its basin supports agriculture and is integral to the region's water supply, particularly with the Aji I dam, which provides drinking water and irrigation resources to Rajkot city. In addition to its primary course, the Aji system feeds several seasonal streams and small tributaries, which contribute to the region's ecological and agricultural productivity.

The **Shetrunji River** flows eastward for a total length of 182 km before meeting the Gulf of Khambhat, with tidal influences extending 5 km upstream from its mouth. The river is fed by nine significant tributaries, of which four—Safara, Shel, Khari, and Talaji—join from the right bank, while five—Stali,

Thebu, Gagadia, Rajwal, and Kharo—originate from the left bank. The left bank drainage system is more extensive, with tributaries like Stali, Thebu, and Gagadia contributing to nearly 34% of the total catchment area. Among these, Gagadia and Theli are principal tributaries that rise from the high grounds near Visavadar Taluka in Junagadh district, underscoring their importance in the Shetrunji's riverine network.

https://guj-nwrws.gujarat.gov.in/downloads/basin_description.pdf

A.4. Climate

Rajkot district has a semi-arid climate, typified by extreme temperatures, erratic rainfall, and high evaporation rates. The region experiences a tropical dry climate, with the summer monsoon season (June to September) being the primary period of precipitation. The average monsoon rainfall is around 500 mm, peaking during July and August. Summers in the district are particularly hot, with temperatures soaring between 40°C and 45°C, especially in May, the hottest month. Winters are relatively mild, with average temperatures ranging from 13°C to 15°C.

The region also faces significant temperature fluctuations between day and night, contributing to high evaporation rates. Wind speed varies throughout the year, but it generally increases during the monsoon, influencing local weather patterns. These meteorological factors heavily impact the region's water availability, agricultural productivity, and overall environmental conditions. Owing to the topographical characteristics climate is variable. In winter the temperature varies between 40°C &150°C. May is the hottest month. Maximum temperature varies between 400°C and 460°C

https://www.cgwb.gov.in/old_website/AQM/NAQUIM_REPORT/Gujarat/Rajkot%20final%20Gujarat.pdf

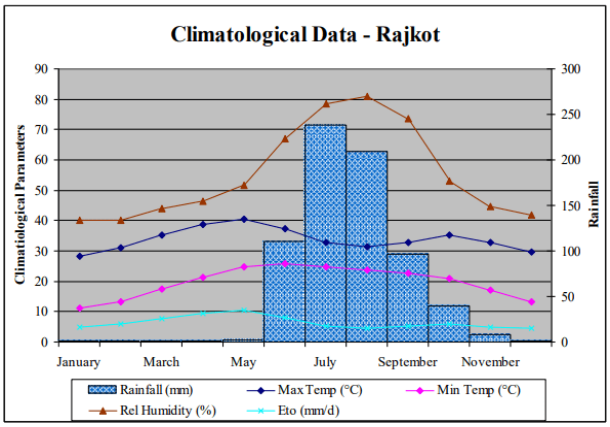


Figure 18: Climatological Data- Rajkot District

Bhavnagar experiences a hot semi-arid climate characterized by distinct seasonal variations. Summers, from March to mid-June, are hot and dry, followed by the monsoon season from mid-June to October, bringing moderate to heavy rainfall. Winters, lasting from November to February, are mild, with average temperatures around 20°C and low humidity. The semi-arid classification of the region is attributed to its

high evapotranspiration rates. Proximity to the sea ensures relatively high humidity levels throughout the year, moderating temperature extremes and contributing to the district's overall climatic pattern.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

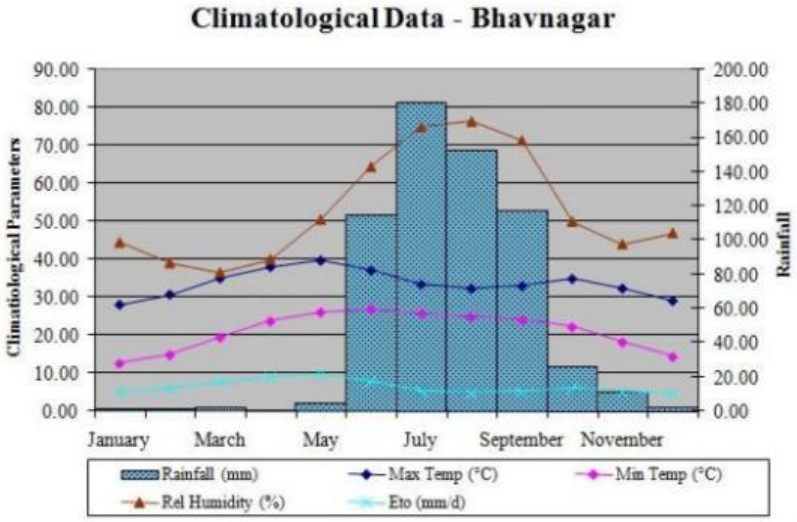


Figure 19: Climatological Data – Bhavnagar District

A.5. Rainfall

Rajkot district has a tropical dry, semi-arid climate with summer monsoon (June to September) being the main rainy season. The mean monsoon rainfall over the district is around 500 mm, with maximum rainfall being experienced during July and August. The number of rainy days (a day with rainfall of 2.5 mm or more) vary from 5 to 10 days a month in July and August. The district receives more than 28 days of rainfall in the entire summer-monsoon season. However, it is observed that the variability in rainy days is higher in July and August.

The average rainfall in **Bhadar basin** is 625 mm. The South West monsoon sets in by the middle of June and withdraws by the first week of October. About 90% of total rainfall is received during July and August.

The average rainfall in the **Machhu basin** is 533.5mm. The South West monsoon sets in by the middle of June and withdraws by the first week of October. About 90% of the total rainfall is received during monsoon months of July – August

https://rajkot.nic.in/economy/,https://shaktifoundation.in/wp-content/uploads/2022/11/Full-Action-Plan-Rajkot.pdf

Table 8: Rainfall Data of Rajkot & Bhavnagar District

Year	Total (mm)	
	Rajkot	Bhavnagar
2022	722.9	566.5
2023	651.0	657.2
2024	1189.333	830.4

Figure 20: Annual Rainfall Map- 2022

https://hydro.imd.gov.in/hydrometweb/(S(4hkzgw45qtw3od551duscx55))/PRODUCTS/Publications/Rainfall%20Statistics%20of%20India%20-%202022/Rainfall%20Statistics%20of%20India%202022.pdf

Bhavnagar district primarily receives rainfall during the southwest monsoon, which typically begins in mid-June and peaks in July and August. The average annual rainfall ranges from 490 mm to 836 mm, with Bhavnagar Taluka recording the highest rainfall at 651 mm and Palitana Taluka the lowest at 352 mm (based on 2014-15 data). According to IMD, the district's normal annual rainfall is 598.4 mm, with approximately 90% of it occurring during the monsoon season across an average of 31 rainy days annually.

The district's tropical climate is generally dry, except in coastal areas, and is divided into four seasons: a hot season (March to May), monsoon (June to September), post-monsoon (October to November), and a cold season (December to February). Rainfall significantly impacts groundwater levels, with most areas experiencing a rise in water levels during the monsoon. However, the south-western region near Amreli and the north-eastern corner of the district sometimes show a decline in water levels despite rainfall.

The Shetrunji basin experiences an average annual rainfall of 604.52 mm, with the South-West monsoon arriving in mid-June and withdrawing by the first week of October. Approximately 90% of the annual

rainfall occurs during July and August. The region's climate is influenced by its topography, leading to variable conditions. Winter temperatures range from 6°C to 18°C, while summer temperatures can soar between 35°C and 47°C.

https://guj-nwrws.gujarat.gov.in/downloads/basin_description.pdf

DSR Bhavnagar District.pdf
https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

https://cdn.s3waas.gov.in/s3ccb0989662211f61edae2e26d58ea92f/uploads/2018/09/2018092869.pdf

A.6. Ground Water

Groundwater is a crucial water source in Gujarat, serving agricultural, municipal, and industrial needs. It lies beneath the Earth's surface, and the depth to groundwater, known as the water table, varies across regions.

According to the 2023 assessment, the Total Annual Ground Water Recharge in Gujarat is 27.35 Billion Cubic Meters (bcm), while the Annual Extractable Ground Water Resource is 25.41 bcm. Groundwater extraction is assessed at 13.13 bcm, yielding a Stage of Ground Water Extraction of 51.68%, which indicates moderate use.

Of Gujarat's 162,778.15 sq km recharge-worthy area, 11.33% (18,448.47 sq km) is categorized as Over-Exploited, 3.23% (5,258.1 sq km) as Critical, 7.06% (11,487.16 sq km) as Semi-Critical, 72.92% (118,697.61 sq km) as Safe, and 5.46% (8,886.8 sq km) as Saline. Similarly, among the 25,405.18 Million Cubic Meters (mcm) of annual extractable groundwater resources, 8.29% (2,105.34 mcm) fall under the Over-Exploited category, 2.92% (743.01 mcm) as Critical, 8.07% (2,050.16 mcm) as Semi-Critical, and 80.72% (20,506.66 mcm) as Safe.

Compared to the 2022 assessment, Gujarat has seen improvements in groundwater metrics. The Total Annual Ground Water Recharge has increased from 26.46 bcm to 27.35 bcm, and the Annual Extractable Resource has risen from 24.58 bcm to 25.41 bcm, attributed to enhanced recharge from canal networks and rainfall. Despite a marginal rise in Annual Ground Water Extraction from 13.09 bcm to 13.13 bcm, the Stage of Ground Water Extraction improved from 53.23% to 51.68%, indicating better groundwater management.

Table 9: Dynamic Ground Water assessment 2023

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2023

GUJARAT

S. No.	Name of District	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Ahmedabad	23822.27	8230.94	0	13896.99	45950.2	3521.59	42428.61	32678.1	3350.94	1020.99	37050.03	-1022.17	12073.57	87.32
2	Amreli	138927.37	6893.14	0	10529.44	156349.95	7817.53	148532.42	73577.7	54.77	1198.3	74830.77	1192.32	73669.8	50.38
3	Anand	31512.49	37179.88	0	47598.47	116290.84	8790.39	107500.45	20627	375.33	3548.55	24550.86	3161.87	82808.29	22.84
4	Arvalli	79638.71	3393.73	0	7191.68	90224.12	4511.2	85712.92	33871.9	25.39	2032.84	35930.13	2144.33	49671.3	41.92
5	Banaskantha	97992.88	14866.25	0	16376.18	129235.31	12509.5	116725.81	130515.1	143.9	4185.04	134844.05	3694.49	14499.03	115.52
7	Bhavnagar	90842.4	7677.03	0	13459.42	111978.85	5598.94	106379.91	42332.1	31.05	3150.66	45513.82	2576.98	60694.55	42.78
27	Rajkot	143424.48	13946.61	0	23456	180827.09	9041.35	171785.74	105382.8	75.98	2515.47	107974.25	2687.82	63639.14	62.85

Table 10: Ground Water Assessment – Rajkot District

Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development- 2023

DISTRICT- RAJKOT

Sr No	Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCES (Ham)				Total Annual Ground water Recharge (3+4+5+6)	Environmental Flows (ham) (5% of 7 for WTF & 10% of 7 for RIF)	Annual Extractable Ground water Resource (ham)	ANNUAL GROUND WATER DRAFT (Ham)				Allocation of Ground Water Resource for Domestic Utilisation for projected year 2025 (ham)	Net Annual Ground Water Availability for Future Use (ham)	Stage of Ground Water Extraction (%)	Categorization of Assessment Unit
		Monsoon		Non Monsoon					Irrigation	Industrial	Domestic	Total Draft (10+11+12)				
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources											
1	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	DHORAJI	9604.33	949.96	0	1498.26	12052.55	602.62	11449.93	8828.30	0.14	226.29	9054.72	241.79	2379.71	79.08	semi_critical
2	GONDAL	33284.67	1866.27	0	3105.87	38256.81	1912.84	36343.97	17247.00	8.04	349.44	17604.48	373.39	18715.54	48.44	safe
3	JAMKANDORNA	12228.38	1201.62	0	1922.31	15352.31	767.62	14584.69	8757.20	0.00	9.71	8766.91	10.37	5817.12	60.11	safe
4	JASDAN	12198	1599.22	0	3034.42	16831.64	841.58	15990.06	14839.00	0.00	723.66	15562.67	773.25	377.80	97.33	critical
5	JETPUR	12769.77	1188.66	0	2067.07	16025.50	801.27	15224.23	9542.70	13.79	439.06	9995.56	469.14	5198.59	65.66	safe
6	KOTADA SANGANI	8232.1	804.13	0	1434.00	10470.23	523.51	9946.72	5618.00	14.49	154.33	5786.81	164.90	4149.34	58.18	safe
7	LODHIKA	6997.49	834	0	1199.56	9031.05	451.55	8579.50	4574.00	6.72	89.33	4670.05	95.45	3903.33	54.43	safe
8	PADDHARI	6786.11	1166.01	0	1807.78	9759.90	488.00	9271.90	6356.90	2.85	152.32	6512.07	162.76	2749.39	70.23	semi_critical
9	RAJKOT	22719.01	1754.8	0	2743.39	27217.20	1360.86	25856.34	12962.80	25.38	0.00	12988.18	0.00	12868.16	50.23	safe
10	RAJKOT URBAN	2335.9	0	0	0.00	2335.90	116.80	2219.10	0.00	0.89	0.00	0.89	0.00	2218.21	0.04	safe
11	UPLETA	10442.95	1295.44	0	2394.57	14132.96	706.65	13426.31	9112.60	3.69	302.30	9418.59	323.01	3987.01	70.15	semi_critical
12	VINCHCHIYA	5825.77	1286.5	0	2248.77	9361.04	468.05	8892.99	7544.30	0.00	69.03	7613.32	73.76	1274.94	85.61	semi_critical
	Rajkot Total	**143424.48**	**13946.61**	**0.00**	**23456.00**	**180827.09**	**9041.35**	**171785.74**	**105382.80**	**75.98**	**2515.47**	**107974.25**	**2687.82**	**63639.14**	**62.85**	**safe**

Rajkot district lacks perennial rivers, relying heavily on surface water sources like canals and groundwater for its water needs. The Narmada canal network serves as an important resource, primarily supplementing drinking water supply, although its contribution to agriculture remains minimal at present. The majority of surface water for irrigation comes from the Aji and Bhadar dams, with Dhoraji having the largest command area under canal irrigation and Rajkot having the highest number of canal irrigation sources. Community ponds, especially in the Jasdan block, also play a significant role in the district's water management system.

Groundwater development in Rajkot is categorized into two primary units: hard rock (basalt) and soft rock (alluvium/sandstone). Groundwater exploration has been ongoing since 1969, with some wells reaching depths of up to 598 meters, particularly in areas like Lodika village. In the basaltic regions, such as Dhoraji, Jetpur, and Kotada Sangani, advanced techniques like remote sensing and geophysical surveys are used to identify viable groundwater zones, helping in the construction of more effective water structures. However, in sandstone areas like Wankaner, groundwater quality tends to be brackish or saline at greater

depths, which poses challenges for sustainable water extraction. Therefore, careful planning is essential to avoid contamination of fresh water zones.

There is also a significant area between Wankaner and Rajkot where Deccan Trap basalt overlays sandstone aquifers. These sandstone aquifers have yet to be fully explored, primarily due to technological limitations in drilling, though some private companies have successfully drilled to depths of 300 meters, revealing high-yield groundwater zones. While the initial results have been promising, further exploration is required, with drilling up to 500 meters recommended to fully assess and tap into these groundwater resources.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Rajkot.pdf

Table 11: Ground Water Potential & Feasible Structures of Rajkot District

Taluka	Wells feasible	Suitable drilling technique	Depth of well (m)	Discharge (Lpm)
Dhoraji, Gondal, Jamkondarna, Jasdan, Jetpur, Kotda Sangni,Lodhika, Paddahari, Rajkot	Dugwell	Manual	10-30	80-150
Tankara, Upleta, Wankaner	Borewells	Down the Hole Hammer (DTH	100-200 (upto 500m in Rajkot city)	100-300
Maliya	Dugwell	Manual	10-25	200-300
	Tubewells	Direct Rotary & Reverse Rotary	50-75	300-500
Morbi, Wankaner	Dugwell	Manual	15-30	200-300
	Tubewells	Direct Rotary & Reverse Rotary	100-200	600-1000

Table 12: Ground Water Assessment – Bhavnagar District

Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development- 2023																
DISTRICT- BHAVNAGAR																
Sr No	Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCES (Ham)				Total Annual Ground water Recharge (3+4+5+6)	Environmental Flows (ham) (5% of 7 for WTF & 10% of 7 for RIF)	Annual Extractable Ground water Resource (ham)	ANNUAL GROUND WATER DRAFT (Ham)				Allocation of Ground Water Resource for Domestic Utilisation for projected year 2025 (ham)	Net Annual Ground Water Availability for Future Use (ham)	Stage of Ground Water Extraction (%)	Categorization of Assessment Unit
		Monsoon		Non Monsoon					Irrigation	Industrial	Domestic	Total Draft (10+11+12)				
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources											
1	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	BHAVNAGAR	8586.72	1172.16	0	1308.60	11067.48	553.38	10514.11	1360.30	0.12	602.47	1962.89	635.28	8518.42	18.67	safe
2	GARIADHAR	6147.18	373.9	0	545.38	7066.46	353.32	6713.14	3563.20	0.39	114.07	3677.66	120.28	3029.27	54.78	safe
3	GHOGHA	4047.85	384.74	0	784.06	5216.65	260.83	4955.82	2624.70	7.90	193.90	2826.50	204.45	2118.76	57.03	safe
4	JESAR	7284.99	436.98	0	646.75	8368.72	418.44	7950.28	2432.00	0.00	0.00	2432.00	0.00	5518.28	30.59	safe
5	MAHUVA	16301.06	1648.46	0	3196.30	21145.82	1057.30	20088.52	8149.40	1.51	1149.97	9300.89	1212.59	10725.01	46.30	safe
6	PALITANA	15854.53	583.74	0	951.23	17389.50	869.47	16520.03	6556.00	2.13	257.35	6815.48	271.36	9690.54	41.26	safe
7	SIHOR	14863.8	443.92	0	754.77	16062.49	803.13	15259.36	6133.10	19.00	0.00	6152.10	0.00	9107.26	40.32	safe
8	TALAJA	10691.11	1921.31	0	4215.82	16828.24	841.40	15986.83	7150.60	0.00	795.30	7945.90	838.60	7997.63	49.70	safe
9	UMRALA	5493.23	427.7	0	654.90	6575.83	328.79	6247.04	3655.90	0.00	0.00	3655.90	0.00	2591.14	58.52	safe
10	VALLABHIPUR	1571.93	284.12	0	401.61	2257.66	112.88	2144.78	706.90	0.00	37.60	744.50	39.65	1398.24	34.71	safe
	Bhavnagar Total	**90842.4**	**7677.03**	**0**	**13459.42**	**111978.85**	**5598.94**	**106379.91**	**42332.10**	**31.05**	**3150.66**	**45513.82**	**3322.21**	**60694.55**	**42.78**	**safe**

The annual groundwater recharge of Bhavnagar district, as per GWRE 2011, is estimated at 942.79 MCM. After reserving 47.13 MCM for environmental and runoff purposes, the net annual groundwater availability is calculated to be 895.65 MCM. The district's gross annual groundwater draft is 573.71 MCM, with irrigation accounting for the majority at 517.33 MCM per year, while 56.38 MCM is utilized for domestic and industrial purposes.

The stage of groundwater development across the district's talukas ranges from 40.74% to 69.72%, categorizing all talukas as Safe based on these development stages and the long-term trends in pre- and post-monsoon groundwater levels. The district's average stage of groundwater development is 64.06%, reflecting a sustainable utilization pattern within the region.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf

A.7 Alternate Methods

The suitable recharge structures feasible in the districts are Percolation tanks/ponds; Recharge wells check dams and nalla bunds etc. depending on the hydrogeological conditions. Large scale artificial recharge schemes may not be feasible due to non-availability of prolific aquifers and paucity of source water. Various rainwater harvesting schemes depending on the suitable hydrogeological conditions have been constructed in the district viz. Check dams, Recharge wells, percolation tanks and ponds, deepening the of the village ponds etc and have shown good impact on the groundwater scenario.

https://dergipark.org.tr/en/download/article-file/1046175#:~:text=The%20suitable%20recharge%20structures%20feasible,resources%20through%20the%20artificial%20recharge.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Rajkot.pdf

Ground Water Related Issues and Problems

1. Fast declining water level
2. Salinity in ground water.
3. High concentration of fluoride in major part of the district.
4. Ground water contamination due to unscientific well construction.
5. Uniformity in pumping pattern is required.

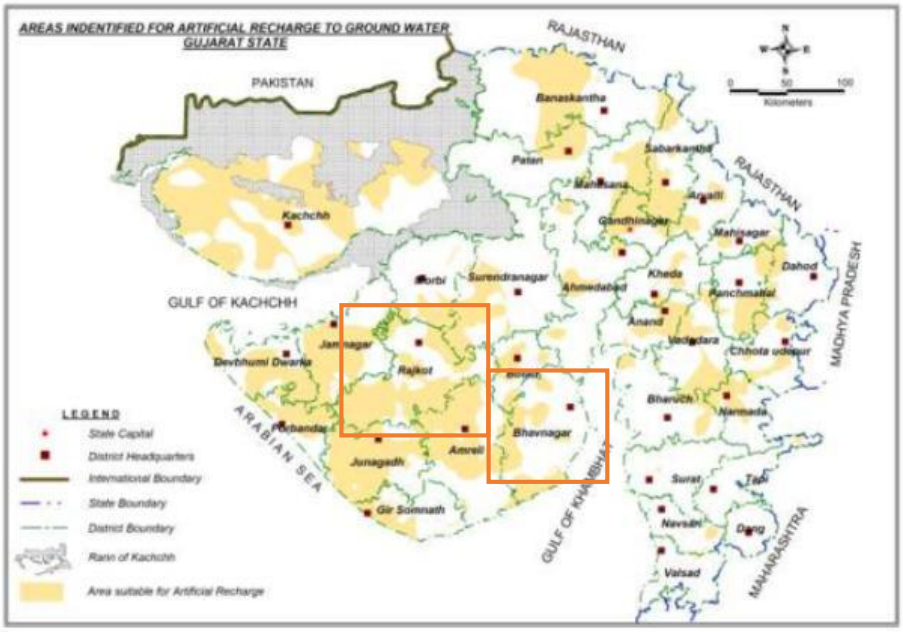


Figure 21: Area identified for Artificial Recharge in Gujarat

https://cgwb.gov.in/cgwbpnm/publication-detail/324

Table 13: Scope of Artificial Recharge in Rajkot & Bhavnagar District

S.No	District	Area of District (Sq.Km.)	Area Identified for AR (Sq.Km.)	Volume of Unsaturated Zone (MCM)	Available Subsurface Space for AR (MCM)	Water Required for Recharge (MCM)	Surplus Available for Recharge (MCM)
7	Bhavnagar	6693.00	2129.10	10161.30	304.84	405.44	20.00
27	Rajkot	7473.83	4707.87	18531.42	555.94	739.40	15.00

https://cgwb.gov.in/cgwbpnm/publication-detail/324

Figure 22: Map showing Groundwater Potential & Artificial Prospects of Rajkot District

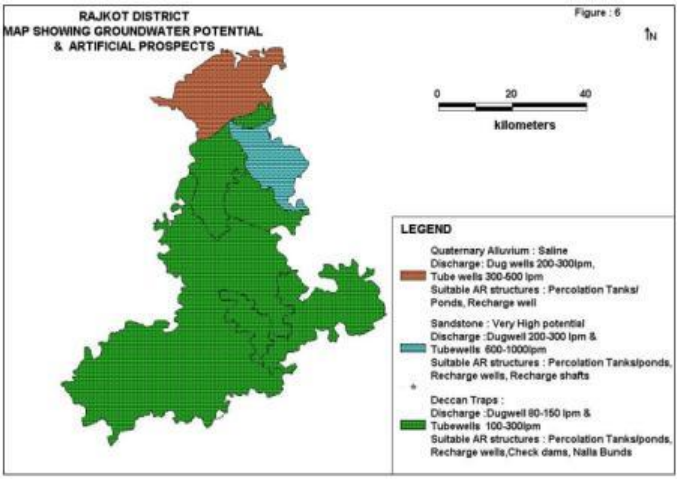


Table 14: Stage of Groundwater Development- Bhavnagar District

Name of Taluka	Available Ground Water Recharge in MCM / Year	Existing Gross Ground Water Draft for all uses in MCM / Year	Stage of Ground Water Development (%)	Category
Bhavnagar	50.27	33.29	69.72	Safe
Botad	110.86	69.20	65.71	Safe
Gadhada	108.34	71.15	69.13	Safe
Gariyadhar	72.12	36.99	54.00	Safe
Ghogha	47.45	30.66	68.02	Safe
Mahuva	141.18	85.66	63.87	Safe
Palitana	94.22	61.16	68.33	Safe
Sihor	92.25	58.06	66.25	Safe
Talaja	123.33	71.88	61.36	Safe
Umarala	60.30	39.18	68.41	Safe
Vallabhipur	42.42	16.42	40.74	Safe
Total	942.79	573.71	64.06	Safe

A.8. Design Specifications

The soils of Bhavnagar and Rajkot districts, both of which play a significant role in agricultural productivity, exhibit a variety of types that impact water retention and groundwater recharge. In Rajkot, the soils are

primarily of Inceptisol and Entisol orders, ranging from clayey loam to clay types, especially in the central and southern talukas. These soils, with their moderate depth and low electrical conductivity, are well-suited for agriculture and retain water effectively, making them ideal for the success of check dam projects. Similarly, in Bhavnagar, the dominant medium black soils, rich in lime, magnesium, and alumina, have excellent moisture retention properties, which are essential for agriculture, especially in drought-prone areas. The presence of alluvial and alkaline soils along the Shetrunji River in Bhavnagar, although less productive due to salinity and alkalinity, still benefits from the water storage and percolation enabled by check dams. By capturing monsoon rainwater, check dams across both districts help reduce runoff, enhance groundwater recharge, and improve water availability for agricultural activities, thus contributing significantly to the sustainable management of water resources and supporting farming in these regions.

https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Bhavnagar.pdf
https://pmksy.gov.in/mis/Uploads/2016/20160816051209369-1.pdf
https://www.cgwb.gov.in/old_website/District_Profile/Gujarat/Rajkot.pdf

Capacity of each check dam catchment area is mentioned in Annexure I.

A.9. Implementation Benefits to Water Security

The Gir Ganga Parivar Trust has successfully implemented a dedicated rainwater harvesting system by constructing a series of check dams in the Rajkot district of Gujarat. This initiative will significantly enhance water conservation efforts and improve groundwater recharge, addressing both agricultural and municipal water needs. By ensuring more sustainable water resource management, the project will help reduce the risk of water scarcity in the region, while also boosting agricultural productivity by improving the water table and providing more reliable irrigation sources

- **Groundwater Recharge and Levels**: Groundwater levels in areas surrounding the check dams have risen significantly, enhancing year-round access to potable water for villages that previously faced severe
- **Extended Water Availability for Agriculture**: Recharged aquifers have provided water availability well beyond the monsoon season, supporting agricultural activities even during dry months.
- **Livelihood Security**: Reliable water supply ensures consistent agricultural output, offering greater livelihood stability, especially during drought-prone years.
- **Extended Cropping Seasons**: Year-round water availability enables multi-season farming, with many farmers now practicing double cropping and incorporating high-value crops like fruits and vegetables.

A9.1 Objectives vs. Outcomes

Objective of the Project Activity

Capture Monsoon Rainwater: The Gir Ganga Parivar Trust aimed to capture and retain monsoon rainwater by constructing a series of check dams across the region. These dams were strategically built to intercept seasonal rainfall, slowing down water flow to prevent rapid runoff and maximize rainwater retention. This allowed more water to percolate into the ground, contributing to local groundwater recharge. By capturing monsoon water, the Trust successfully created a sustainable water reserve that improved year-round water availability, particularly benefiting agriculture and drinking water needs during dry periods in the drought-prone areas.

Groundwater Recharge: The PP's objective was to recharge local aquifers through the construction of check dams, which allowed rainwater to percolate into the ground, replenishing groundwater reserves and raising local water tables. These structures were designed to slow down water flow, encouraging deep soil infiltration that effectively boosted groundwater levels. By implementing this project, the Trust addressed the critical need for a stable, long-term water supply, supporting both drinking water access and agricultural activities in nearby communities, particularly during drought-prone periods. This objective was central to creating sustainable water security for the region.

Improve Water Availability: PP has worked towards improving water availability by constructing check dams that store monsoon rainwater, creating a reliable, year-round water source. By capturing and holding rainwater, these structures provide essential support for both drinking and agricultural needs in the region. This stored water is crucial for maintaining a steady water supply throughout the year, especially during dry seasons, ensuring that nearby communities and farms have consistent access to water and helping to alleviate the stress of drought conditions in Saurashtra.

Support Agricultural Activities: PP aimed to enhance agricultural sustainability by providing a dependable water supply through check dam construction. By storing rainwater, these structures ensured a steady source of irrigation, particularly during dry months, which is critical for farming in the drought-prone Saurashtra region. This reliable water availability has helped farmers maintain crop production year-round, reducing the impact of drought conditions and supporting local agriculture and food security.

Reduce Runoff: PP focused on minimizing water runoff through the construction of check dams, which slow down water flow and promote infiltration. By doing so, these dams help minimize soil erosion, preserving topsoil essential for agriculture and maintaining local land health. Additionally, by retaining rainwater within the local environment, these structures contribute to long-term water security, allowing more water to percolate into the ground and sustain both the ecosystem and community water needs during dry periods.

Outcome of the Post-Project Activities:

- **Expanded Irrigated Farmland**: Check dams have increased the area of irrigated farmland, allowing farmers to cultivate more efficiently.
- **Improved Crop Yields and Diversification**: Farmers can now grow higher-value, water-intensive crops and increase yields of key crops.
- **Extended Cropping Seasons**: Year-round water availability enables multi-season farming, with many farmers now practicing double cropping and incorporating high-value crops like fruits and vegetables.
- **Vegetation Regrowth**: Areas that were barren during dry months now support native vegetation, bolstering local biodiversity.
- **Improved Public Health**: Cleaner water has reduced waterborne diseases, positively impacting community health.
- **Job Creation**: The construction and maintenance of check dams provided initial jobs, with ongoing employment opportunities in agriculture and agro-processing.
- **Increased Income**: Higher crop productivity and diversified crops raise household incomes.
- **Public Health Improvements**: Access to cleaner water has reduced waterborne diseases, leading to noticeable public health improvements.
- **Increased Household Incomes**: Higher agricultural productivity has led to improved incomes and living standards.
- **Reduced Migration**: Reliable water access and enhanced farm productivity have lessened seasonal migration, allowing rural families to remain local.

Conclusion:

The rainwater harvesting initiative by the PP through the construction of check dams has proven to be a transformative solution for the region. The project has successfully enhanced groundwater recharge, improved water availability for agricultural and domestic use, and mitigated the impacts of drought conditions in Saurashtra.

It has also led to significant positive outcomes, including increased agricultural productivity, diversification of crops, and improved public health. Additionally, the project has created local employment opportunities, reduced migration, and bolstered the overall socio-economic stability of the community.

A.9.2 Interventions by Project Proponent

The Gir Ganga Parivar Trust (PP) has made notable strides in improving water management in the Rajkot and Bhavnagar district of Gujarat by implementing a dedicated rainwater harvesting system. This system includes the construction of a series of check dams designed to enhance water conservation and groundwater recharge. By capturing rainwater runoff during the monsoon season, these check dams

provide a reliable source of irrigation, help raise the water table, and support both agricultural and municipal water needs. The Trust's efforts are key in addressing the region's water scarcity challenges and fostering agricultural productivity.

In addition to construction, the Trust is committed to maintaining and restoring these check dams, ensuring that they continue to function effectively and sustainably. Through careful management of the catchment areas and ensuring optimal water flow, PP is helping safeguard local water resources, promote soil conservation, and improve long-term water availability for communities in the region.

A.10. Feasibility Evaluation

The rainwater harvesting system and check dams implemented by the PP is designed to effectively manage seasonal rainfall and provide consistent water storage for the region. These structures are built to accommodate fluctuating water flows, ensuring that excess runoff is captured during the monsoon season while preventing soil erosion and promoting groundwater recharge.

The project has had a positive impact on the local ecosystem, creating new water reservoirs that support both plant and animal life, fostering a thriving habitat for local biodiversity. The check dams not only improve agricultural productivity but also enhance the environmental quality of the region, making it more resilient to water scarcity.

A.11. Ecological Aspects & Sustainable Development Goals (SDGs):

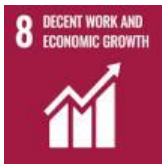
The ecological impact of the rainwater harvesting project, through check dams in Saurashtra, has significantly benefited both the environment and local communities. By capturing monsoon rainwater, these structures help prevent soil erosion, recharge groundwater, and improve soil health.

The retained water encourages the growth of native vegetation, restoring barren lands and creating wildlife habitats. Additionally, by reducing runoff, these check dams help preserve agricultural land and maintain sustainable farming practices.

This system also contributes to better air quality and enhances climate resilience, securing vital water and food resources for local communities.

Sustainable Development Goal (SDG)	Most relevant SDG Target / SDG Impact	Compliance Activities
 **SDG 2: Zero Hunger**	**Target 2.3** Double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge,	By improving agricultural productivity through better irrigation, the project supports food security for local farmers and enhances crop yields, addressing hunger and malnutrition.

	financial services, markets and opportunities for value addition and non-farm employment **Target 2.4** Ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	
 **SDG 3: Good Health and Well-being**	**Target 3.9** Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Improved access to clean water has significantly reduced waterborne diseases, enhancing public health and overall well-being in the community.
 **SDG 6: Clean Water and Sanitation**	**Target 6.6** By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes **Target 6.4** By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	The check dams enhance water security by efficiently collecting and storing rainwater, ensuring better access to clean water for local communities, and promoting sustainable water management practices.

 **SDG 8: Decent Work and Economic Growth**	**Target 8.3** Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	The project creates economic opportunities for local farmers by improving their livelihoods through enhanced agricultural productivity, contributing to inclusive economic growth.
 **SDG 12: Responsible Consumption and Production**	**Target 12.2** Achieve the sustainable management and efficient use of natural resources	The use of harvested rainwater for various needs reduces dependence on groundwater and promotes efficient water use in industrial processes.
 **SDG 13: Climate Action**	**Target 13.1** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries **Target 13.2** Integrate climate change measures into national policies, strategies and planning	The project contributes to climate resilience by improving groundwater levels and promoting sustainable land use practices, which help mitigate the impacts of climate change, such as droughts.
 **SDG 15: Life on Land**	**Target 15.1** By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements **Target 15.3** By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	The check dams enhance biodiversity by creating habitats for various species, supporting the conservation of terrestrial ecosystems.

 **SDG 17: Partnerships for the Goals**	**Target 17.13** Enhance global macroeconomic stability, including through policy coordination and policy coherence	Engaging with local communities and stakeholders fosters collaboration, strengthening partnerships that are essential for achieving sustainable development.

A.12. Recharge Aspects:

A.12.1 Solving for Recharge

Ultimately, the volume of groundwater recharge benefit to the sub basin is the most critical aspect for such MAR activities. Groundwater recharge is quantified as the deep percolation of surface water applied during project implementation. Using a field-scale water budget, deep percolation can be calculated as the difference between all other inflows and outflows, per the equation below, with each other inflow and outflow being quantified:

Recharge = Rainfall + Surface Inflow – Evapotranspiration – Surface Outflow – Change in Storage

Evapotranspiration & Other Data: https://datameet-pune.github.io/open-water-data/docs/open-water-data-paper.pdf (or available under Documents Section- Water Data Guide)

Root Zone = the root zone is comprised of the upper portion of the soil where water extraction by roots occurs, above the depth at which water infiltrates to the groundwater system. The depth to the bottom of the root zone varies by crop, but typically extends up to seven feet.

Surface Inflow= Surface inflows can be either directly measured or calculated from measured values. In fields directly served by metered lift pumps or metered gates, the volume of surface inflows to the field can be directly measured or calculated from totalized measurements. Typical accuracies of pipe flow measurements range from 1-12 percent. In fields that are indirectly supplied with surface water, surface inflows may need to be calculated from upstream and downstream flow measurements, or through theoretical or empirical equations relating available data to field surface inflows. For example, fields served from canals measured using weirs, or fields served from canals that deliver water to multiple locations downstream of a measurement device may require site-specific calculations to quantify surface inflows to a specific field. Low-cost in-field measurements can also be made by setting up flashboards at the measurement location and correlating the “runup” of an unsubmerged weir overflow on a flat weir stick to the flow rate using standardized equations. Typical accuracies of “runup” or indirect flow

measurements may exceed 10 percent, depending on site conditions and the accuracy of measurement data.

To monitor surface inflows, project owners may record flow data, maintain irrigation logs, and maintain logs of any other parameters required to calculate field deliveries, depending on the unique conditions of their field. Project owners may also consider using mobile flow monitoring equipment to measure or verify surface inflows.

Surface Outflows: To monitor surface outflows, users may record flow data or water level data and maintain logs of any other parameters required to calculate outflows, depending on the unique conditions of their project activity. Pressure transducers and dataloggers may be used to automatically monitor water levels, or users may install wooden stakes to manually monitor water depths.

Change in Storage = the change in surface storage, or average ponded water depth, can be calculated from measured and observed changes in water surface levels at points throughout the project field. Over the annual project implementation period, **the total change in surface storage is typically zero**, provided that the surface of a field is dry and free of ponded water at the start and end of the project.

While the uncertainty of each inflow and outflow will vary based on field conditions and measurement devices, typical uncertainties associated with each water budget component are summarized in the table below. The uncertainty of deep percolation (i.e., recharge) can then be calculated from these other uncertainties, for example following the process described by Clemmens and Burt (1997).

Users can use the following table to eliminate uncertainty from their estimates.

Water Budget Component	Typical Estimated Uncertainty (%)	Description
Surface Inflow	5%	Typical range of accuracy from meters to minimum delivery accuracy requirements of delivery and diversion measurement devices.
Precipitation	3%	Typical range of accuracy from field-level rain gauges to extrapolation of local weather station data
Surface Outflow	5%	Typical range of accuracy from meters to estimated outflow relationships
Evapotranspiration	20%	Clemmens and Burt, 1997; typical accuracy based on free water surface evaporation coefficient.
Deep Percolation	5%	Typical range of calculated accuracy from field-scale water budget results (fields ranging from 56 to 125 acres)
Total	**38%**	

A.13. Quantification Tools

The baseline scenario is the situation where, in the absence of the project activity, unutilized rainwater flows uncollected into drains or is not conserved and harvested within the project boundary and hence remains unutilized.

Baseline scenario, if not directly measurable, is calculated by using the UWR Standard. PP has selected the following method from UWR standard

Harvesting potential or Volume of water utilized (liters) = Area of Catchment/Roof/Collection Zone (m^2) X Amount of rainfall (mm) X Runoff coefficient*uncertainty Factor (1-0.38= 0.62)

As per UWR Standard

Runoff coefficient

Runoff coefficient for any catchment is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface. Runoff coefficient accounts for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all contribute to reducing the amount of runoff. Runoff coefficient varies from 0.5 to 1.0. Rooftop rain water harvesting systems shall use the runoff coefficient equal to 1 as the rooftop area is totally impervious. Eco-climatic conditions (i.e. Rainfall quantity & Rainfall pattern) and the catchment characteristics are considered to be most important factors affecting rainwater harvesting potential.

Type of Area	Recommended Runoff Coefficient (K)
Residential	0.3 to 0.5
Forest	0.5 to 0.2
Commercial & Industrial	0.9
Parks and Farms	0.05- 0.3
Asphalt or Concrete Paving	0.85
Road surface	0.8-0.9

Annual Rainwater harvesting Potential

Annual rainwater harvesting potential is given by $V = K \times I \times A$

Where, V=Volume of water that can be harvested annually in liters.

K = Runoff coefficient

I = Annual rainfall in (mm)

A = Catchment area in (m^2)

Runoff Coefficient (K) selected = 0.3

Rainfall infiltration method

In areas where ground water level monitoring is not adequate in space and time, rainfall infiltration may be adopted. The norms for rainfall infiltration contributing to ground water recharge are evolved, based on the studies undertaken in various water balance projects in India. The norms for recharge from rainfall under various hydrogeological situations are recommended in the following table.

Rainfall infiltration method

In areas where ground water level monitoring is not adequate in space and time, rainfall infiltration may be adopted. The norms for rainfall infiltration contributing to ground water recharge are evolved, based on the studies undertaken in various water balance projects in India. The norms for recharge from rainfall under various hydrogeological situations are recommended in the following table

Table : Rainfall infiltration factor in different hydrogeological situations

S.No	Hydrogeological situation	Rainfall infiltration factor
1	Alluvial areas	
	a. Sandy Areas	20 to 25 percent of normal rainfall
	b. Areas with higher clay content	10 to 20 percent of normal rainfall
2	Semi-Consolidated Sandstones (Friable and highly porous)	10 to 15 percent of normal rainfall
3	Hard rock area	
	a. Granitic Terrain	
	(i) Weathered and Fractured	10 to 15 percent of normal rainfall
	(ii) Un-Weathered	5 to 10 percent of normal rainfall
	b. Basaltic Terrain	
	(I) Vesicular and Jointed Basalt	10 to 15 percent of normal rainfall
	(ii) Weathered Basalt	4 to 10 percent of normal rainfall
	c. Phyllites, Limestones, Sandstones, Quartzites, Shales, etc.	3 to 10 percent of normal rainfall

Additional Guidance on Groundwater Recharge estimates and guidelines:

UWR recommends following the estimates and guidelines outlined here http://cgwb.gov.in/documents/Manual%20on%20Artificial%20Recharge%20of%20Ground%20Water.pdf

Interim Report on Project wise Impact Assessment of Completed Demonstrative Artificial Recharge Projects of XI Plan (http://cgwb.gov.in/Ar-reports.html)

Quantification of RoUs:

YEAR 2022

Sr. No.	Total Rainfall	Total Volume in Litre	RoUs
1	566.5	21284.538	21
2	566.5	31821.438	31
3	566.5	61430.127	61
4	566.5	28976.475	28
5	566.5	31399.962	31
6	566.5	32769.759	32
7	566.5	37616.733	37
8	566.5	45730.146	45
9	566.5	68489.85	68
10	566.5	27079.833	27
11	566.5	20546.955	20
12	566.5	40672.434	40
13	566.5	44781.825	44
14	566.5	36036.198	36
15	566.5	37195.257	37
16	566.5	64907.304	64
17	566.5	24761.715	24
18	566.5	31399.962	31
19	566.5	36246.936	36
20	566.5	23918.763	23
21	722.9	24874.989	24
22	722.9	34556.0658	34
23	722.9	30791.2026	30
24	722.9	36976.335	36
25	722.9	31463.4996	31
26	722.9	490238.9724	490
27	722.9	1512668.25	1512
28	722.9	523719.363	523

29	722.9	1883776.194	1883
30	722.9	55128.354	55
31	722.9	100593.1109	100
32	722.9	104743.8726	104
33	722.9	594678.9668	594
34	722.9	314089.0908	314
35	722.9	247321.9312	247
36	722.9	238860.4011	238
37	722.9	356689.8625	356
38	722.9	886865.9659	886
39	722.9	41413.4952	41
40	722.9	130963.4556	130
41	722.9	55128.354	55
42	722.9	29581.068	29
43	722.9	125316.1608	125
44	722.9	41547.9546	41
45	722.9	31732.4184	31
46	722.9	38455.3884	38
47	722.9	174797.22	174
48	722.9	26622.9612	26
49	722.9	25278.3672	25
50	722.9	76776.3174	76
51	722.9	20168.91	20
TOTAL			**9004**

YEAR 2023

Sr.No.	Total Rainfall	Total Volume in Litre	RoUs
1	657.2	24692.3184	24
2	657.2	36916.2384	36
3	657.2	71265.4536	71
4	657.2	33615.78	33
5	657.2	36427.2816	36
6	657.2	38016.3912	38
7	657.2	43639.3944	43
8	657.2	53051.8128	53
9	657.2	79455.48	79
10	657.2	31415.4744	31
11	657.2	23836.644	23

12	657.2	47184.3312	47
13	657.2	51951.66	51
14	657.2	41805.8064	41
15	657.2	43150.4376	43
16	657.2	75299.3472	75
17	657.2	28726.212	28
18	657.2	36427.2816	36
19	657.2	42050.2848	42
20	657.2	27748.2984	27
21	651	22400.91	22
22	651	31119.102	31
23	651	27728.694	27
24	651	33298.65	33
25	651	28334.124	28
26	651	441479.556	441
27	651	1362217.5	1362
28	651	471629.97	471
29	651	1696414.86	1696
30	651	49645.26	49
31	651	90588.06918	90
32	651	94325.994	94
33	651	535531.8956	535
34	651	282849.6308	282
35	651	222723.1667	222
36	651	215103.2247	215
37	651	321213.3082	321
38	651	798657.8279	798
39	651	37294.488	37
40	651	117937.764	117
41	651	49645.26	49
42	651	26638.92	26
43	651	112852.152	112
44	651	37415.574	37
45	651	28576.296	28
46	651	34630.596	34
47	651	157411.8	157
48	651	23975.028	23
49	651	22764.168	22
50	651	69140.106	69
51	651	18162.9	18

52	651	72651.6	72
53	651	109219.572	109
54	651	56062.818	56
55	651	71198.568	71
56	651	13805.98355	13
57	651	6013.372932	6
58	651	3896.305308	3
59	651	38084.69524	38
60	651	6035.894928	6
61	651	17522.11289	17
62	651	7184.516724	7
63	651	22521.996	22
64	651	20022.05444	20
65	651	7274.604708	7
66	651	16868.975	16
67	651	24774.1956	24
68	651	5517.88902	5
69	651	1651785.709	1651
70	651	8670.96846	8
71	651	435485.3147	435
72	651	50404.22705	50
73	651	4369.267224	4
TOTAL			10943

YEAR 2024

Sr.No.	Total Rainfall	Total Volume in Litre	RoUs
1	830.4	31199.7888	31
2	830.4	46645.2288	46
3	830.4	90046.9152	90
4	830.4	42474.96	42
5	830.4	46027.4112	46
6	830.4	48035.3184	48
7	830.4	55140.2208	55
8	830.4	67033.2096	67
9	830.4	100395.36	100
10	830.4	39694.7808	39
11	830.4	30118.608	30

12	830.4	59619.3984	59
13	830.4	65643.12	65
14	830.4	52823.4048	52
15	830.4	54522.4032	54
16	830.4	95143.9104	95
17	830.4	36296.784	36
18	830.4	46027.4112	46
19	830.4	53132.3136	53
20	830.4	35061.1488	35
21	1189.333	40924.94853	40
22	1189.333	56852.49607	56
23	1189.333	50658.4498	50
24	1189.333	60834.38295	60
25	1189.333	51764.52949	51
26	1189.333	806553.3099	806
27	1189.333	2488679.303	2488
28	1189.333	861636.0785	861
29	1189.333	3099235.291	3099
30	1189.333	90698.53458	90
31	1189.333	165498.2797	165
32	1189.333	172327.2157	172
33	1189.333	978380.5776	978
34	1189.333	516747.1582	516
35	1189.333	406900.172	406
36	1189.333	392979.0531	392
37	1189.333	586835.0038	586
38	1189.333	1459093.872	1459
39	1189.333	68134.5089	68
40	1189.333	215464.3236	215
41	1189.333	90698.53458	90
42	1189.333	48667.50636	48
43	1189.333	206173.2542	206
44	1189.333	68355.72484	68
45	1189.333	52206.96137	52
46	1189.333	63267.75827	63
47	1189.333	287580.7194	287
48	1189.333	43800.75572	43
49	1189.333	41588.59634	41

50	1189.333	126314.3006	126
51	1189.333	33182.3907	33
52	1189.333	132729.5628	132
53	1189.333	199536.7761	199
54	1189.333	102422.9793	102
55	1189.333	130074.9715	130
56	1189.333	135605.37	135
57	1189.333	59064.65545	59
58	1189.333	38270.35727	38
59	1189.333	374076.1512	374
60	1189.333	59285.87138	59
61	1189.333	172105.9998	172
62	1189.333	70567.88422	70
63	1189.333	221215.938	221
64	1189.333	196660.9689	196
65	1189.333	71452.74797	71
66	1189.333	165690.7376	165
67	1189.333	243337.5318	243
68	1189.333	54197.90481	54
69	1189.333	16224198.11	16224
70	1189.333	85168.13613	85
71	1189.333	4277431.377	4277
72	1189.333	495081.2692	495
73	1189.333	42915.89197	42
74	1189.333	131181.0512	131
75	1189.333	41588.59634	41
76	1189.333	4015511.707	4015
77	1189.333	3518881.926	3518
78	1189.333	975119.8547	975
79	1189.333	1831446.751	1831
80	1189.333	1160720.027	1160
81	1189.333	878890.9217	878
82	1189.333	5198353.327	5198
83	1189.333	4214606.051	4214
84	1189.333	1214917.931	1214
TOTAL			**61422**

Year	Crediting Period (DD/MM/YYYY)	RoUs (1000 Litres)/Year
		Total
2022	3/3/2022-31/12/2022	9004
2023	1/1/2023-31/12/2023	10943
2024	1/1/2024-31/12/2024	61422
Total		**81369**

A.14. UWR Rainwater Offset Do No Net Harm Principles

PP has implemented a pioneering rainwater harvesting initiative through the construction of check dams in the Saurashtra region, addressing critical water challenges in this drought-prone areas Rajkot and Bhavnagar.

These check dams are strategically placed to capture monsoon rainfall, slowing water runoff and ensuring maximum retention for groundwater recharge. This effort has resulted in a steady and reliable water supply, benefiting both agricultural and domestic needs throughout the year.

By reducing soil erosion and preserving topsoil, the project has enhanced land fertility, while the increased water availability has allowed farmers to adopt multi-season cropping and diversify into higher-value crops. The initiative has also created new habitats for native vegetation and wildlife, revitalizing the local ecosystem. Beyond environmental benefits, the project has bolstered community livelihoods by reducing migration, creating employment opportunities, and improving public health through better water quality.

This integrated approach has transformed water management in the region, promoting sustainability and long-term resilience.

A.15. Scaling Projects

Small water conservation structures like check dams play a crucial role in addressing water scarcity, particularly in regions like Gujarat, which faces significant challenges due to limited freshwater resources. These check dams help capture rainwater during the monsoon season and retain it at the source, preventing water from flowing away. This stored water can then be pumped for irrigation, benefiting agriculture and rural livelihoods. In addition to water storage, the process also aids in recharging groundwater reserves, making water accessible through hand pumps and wells.

In Gujarat, where water scarcity is compounded by pollution and high demand for water across agricultural, industrial, and domestic sectors, the need for effective water management is more critical than ever. To tackle these issues, PP has built **84 check dams** in water-stressed areas like Rajkot and Bhavnagar. These structures not only improve water availability but also support sustainable agriculture by providing reliable irrigation sources.

As a result, farmers in these regions experience more consistent crop yields despite fluctuating rainfall patterns. By addressing water scarcity and promoting sustainable practices, the trust's work serves as a model for tackling water challenges in other parts of the country.

https://www.downtoearth.org.in/water/saurashtra-woes-policy-change-on-check-dams-leads-to-water-deficit-64073 https://indiacsr.in/csr-big-impact-check-dams-empowering-lives-gujarat/

Annexure I – Capacity of Catchment area

Figure 23 Consent Letter- Jetukuba, Lodhika, Rajkot

Sr. No.	Gaam/Taluka	Address	Coordinates	Commissioning Date	Capacity (in cubic meter)
1	Jetukuba, Lodhika	જેતકુબા નુ પાટિયું , ચાંદલી રોડ	22.132350 - 70.604269	6/28/2022	1676.4
2	Jetukuba, Lodhika	વલ્લભભાઈ ની વાડી ની બાજુમાં	22.130283 - 70.601070	7/20/2022	871.728
3	Jetukuba, Lodhika	હનુમાન મંદીર ની સામે/ ગામ તર નું ચેકડેમ	22.119218 - 70.578256	7/20/2022	4754.88
4	Jetukuba, Lodhika	પરેશભાઈ ની વાડી ની સામે	22.128832 - 70.598593	7/22/2022	687.6288
5	Jetukuba, Lodhika	ગામ ની બાજુમાં ડાંગરવાડા બાજુ નદીમાં	22.119498 - 70.577236	6/4/2022	3561.588
6	Jetukuba, Lodhika	ચાંદલી ના રસ્તે , જિલ્લા ની બાજુમાં	22.129938 - 70.584320	6/20/2022	1249.68
7	Jetukuba, Lodhika	ગામ ની બાજુમાં ડાંગરવાડા રસ્તે	22.119498 - 70.577236	6/28/2022	2840.736
8	Jetukuba, Lodhika	ખોડાભાઈની વાડીની બાજુમાં	22.132238 - 70.577172	6/29/2022	847.6488
9	Jetukuba, Lodhika	દિનેશભાઇ ઉપસરપંચની વાડીની બાજુમાં	22.128470 - 70.579767	5/5/2023	896.112
10	Jetukuba, Lodhika	લોધિકા ના રસ્તે ચંદન વાડી સામે	22.125823 - 70.586048	5/7/2023	1760.22
11	Jetukuba, Lodhika	વલ્લભભાઈ ની વાડી ની બાજુમાં	22.129248 - 70.599208	7/20/2022	603.504

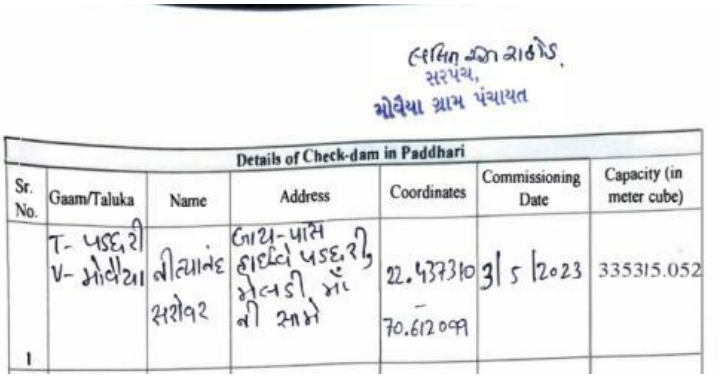
સરપંચ
શ્રી જેતકુબા ગ્રા. પં.

Figure 24 Consent Letter- Kagdadi, Rajkot

Details of Check-dam in Kagdadi					
Sr. No.	Gaam/Taluka	Address	Coordinates	Commissioning Date	Capacity (in cubic meter)
1	Kagdadi	રમેશભાઈની વાડીની બાજુમાં	22.467306 - 70.773874	8/31/2022	457.2
2	Kagdadi	રમેશભાઈ લીંબાસીયા ની વાડીની બાજુમાં	22.473321 - 70.779743	9/1/2022	676.656
3					0
4	Kagdadi	જગદીશ નસિતની વાડીની બાજુમાં	22.494913 - 70.763823	9/24/2022	2116.836
5	Kagdadi	જગદીશ નસિતની વાડીની ઉપરના ભાગમાં	22.492503 - 70.764749	9/24/2022	2688.336
6	Kagdadi	સુરેશભાઇ ની વાડીની બાજુ	22.481695 - 70.776141	9/25/2022	651.0528
7	Kagdadi	વલ્લભભાઈ લીંબાસીયાની વાડી વાડો સેઢો	22.474103 - 70.786134	9/22/2022	1463.04
8	Kagdadi	પરષોત્તમભાઈની વાડી પાસે	22.485055 - 70.783989	9/24/2022	1868.424
9	Kagdadi	શૈલેશભાઈ ની વાડી બાજુ	22.486261 - 70.782880	9/22/2022	3299.1552
10	Kagdadi	ખોડાભાઈ ની વાડીની બાજુમાં	22.500338 - 70.776495	6/29/2022	575.4624
11	Kagdadi	વિનોદભાઇ શંખવરાની વાડીની બાજુમાં	22.498727 - 70.776495	9/1/2022	940.0032
12	Kagdadi	જીતુભાઈ શંખવરાની વાડીની બાજુમાં	22.483719 - 70.790534	9/1/2022	628.1928
13	Kagdadi	મુકેશભાઇ શંખવરાની વાડીની બાજુમાં	22.474524 - 70.781041	9/1/2022	670.56

સરપંચ
કગદડી ગ્રામ પંચાયત

Figure 25 Consent Letter- Paddhari, Rajkot

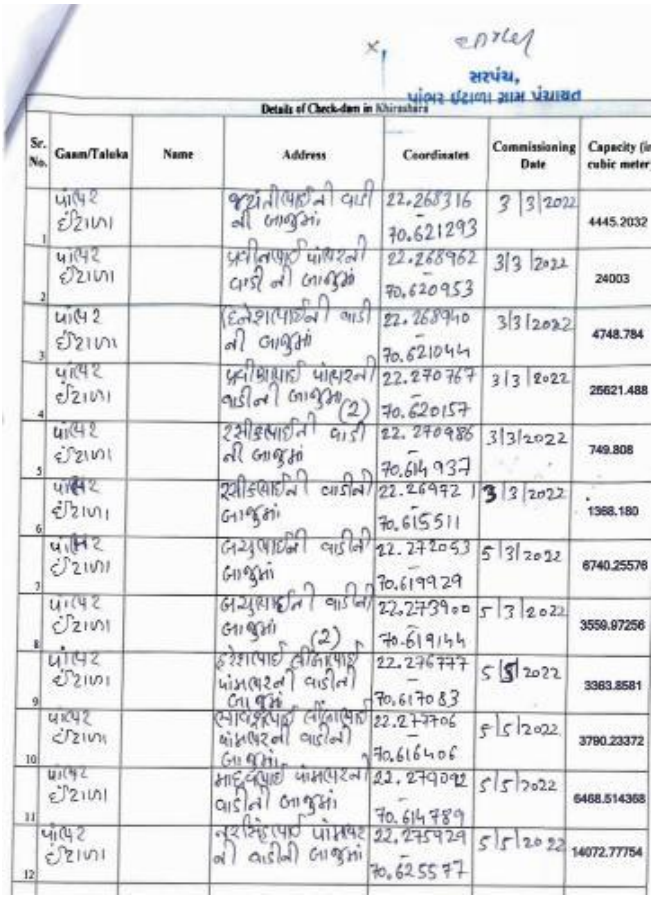


હસ્તિ શ્રી રાઠોડ
સરપંચ,
મોવૈયા ગ્રામ પંચાયત

Details of Check-dam in Paddhari

Sr. No.	Gaam/Taluka	Name	Address	Coordinates	Commissioning Date	Capacity (in meter cube)
1	T- પડધરી V- મોવૈયા	નીલાનંદ સરોવર	ગોચર-પાસે હાર્દિકો પડધરી, મેલડી માં ની સામે	22.437310 70.612099	3|5|2023	335315.052

Figure 26 Consent Letter- Pambhar Itada, Rajkot

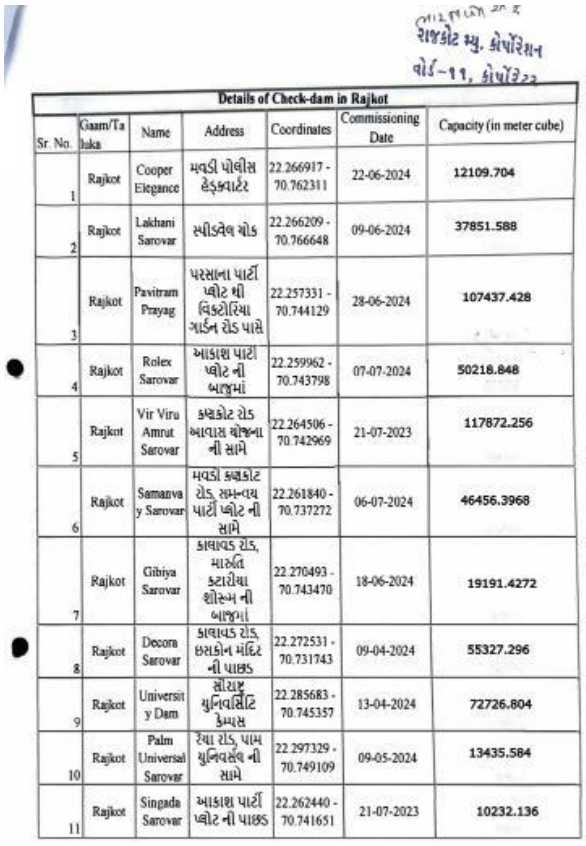


સરપંચ,
પાંભર ઇંટાળા ગ્રામ પંચાયત

Details of Check-dam in Khirasara

Sr. No.	Gaam/Taluka	Name	Address	Coordinates	Commissioning Date	Capacity (in cubic meter
1	પાંભર ઇંટાળા		જીવાભાઈની વાડી ની બાજુમાં	22.268316 70.621293	3|3|2022	4445.2032
2	પાંભર ઇંટાળા		પ્રવીણભાઈ પાંભરની વાડી ની બાજુમાં	22.268962 70.620953	3|3|2022	24003
3	પાંભર ઇંટાળા		દિનેશભાઈની વાડી ની બાજુમાં	22.268940 70.621044	3|3|2022	4748.784
4	પાંભર ઇંટાળા		પ્રવીણભાઈ પોપટની વાડીની બાજુમાં (2)	22.270767 70.620157	3|3|2022	25621.488
5	પાંભર ઇંટાળા		રમેશભાઈની વાડી ની બાજુમાં	22.270986 70.614937	3|3|2022	749.808
6	પાંભર ઇંટાળા		રમેશભાઈની વાડીની બાજુમાં	22.26992 70.615511	3|3|2022	1368.180
7	પાંભર ઇંટાળા		ભરતભાઈની વાડીની બાજુમાં	22.272053 70.619929	5|3|2022	6740.25576
8	પાંભર ઇંટાળા		ભરતભાઈની વાડીની બાજુમાં (2)	22.273900 70.619144	5|3|2022	3559.97256
9	પાંભર ઇંટાળા		રમેશભાઈ વીરજીભાઈ પાંભરની વાડીની બાજુમાં	22.276777 70.617083	5|5|2022	3383.8581
10	પાંભર ઇંટાળા		ચંપાબેનબેન વીરજીભાઈ પાંભરની વાડીની બાજુમાં	22.273706 70.616406	5|5|2022	3790.23372
11	પાંભર ઇંટાળા		મગનભાઈ પાંભરની વાડીની બાજુમાં	22.274092 70.614789	5|5|2022	6468.514368
12	પાંભર ઇંટાળા		નરસિંહભાઈ પોપટની વાડીની બાજુમાં	22.275429 70.625577	5|5|2022	14072.77754

Figure 27 Consent Letter- Rajkot



રાજકોટ મ્યુ. કોર્પોરેશન
વોર્ડ-૧૧, કોર્પોરેટર

Details of Check-dam in Rajkot

Sr. No.	Gaam/Taluka	Name	Address	Coordinates	Commissioning Date	Capacity (in meter cube)
1	Rajkot	Cooper Elegance	મવડી પોલીસ હેડક્વાર્ટર	22.266917 - 70.762311	22-06-2024	12109.704
2	Rajkot	Lakhani Sarovar	સ્પીડવેલ ચોક	22.266209 - 70.766648	09-06-2024	37851.588
3	Rajkot	Pavitram Prayag	પરસાળા પાર્ટી પ્લોટ થી વિક્ટોરિયા ગાર્ડન રોડ પાસે	22.257331 - 70.744129	28-06-2024	107437.428
4	Rajkot	Rolex Sarovar	આકાશ પાર્ટી પ્લોટ ની બાજુમાં	22.259962 - 70.743798	07-07-2024	50218.848
5	Rajkot	Vir Viru Amrut Sarovar	કણકોટ રોડ આવાસ યોજના ની સામે	22.264506 - 70.742969	21-07-2023	117872.256
6	Rajkot	Samanva y Sarovar	મવડી કણકોટ રોડ, સમન્વય પાર્ટી પ્લોટ ની સામે	22.261840 - 70.737272	06-07-2024	46456.3968
7	Rajkot	Gibiya Sarovar	કાલાવડ રોડ, માર્કેટ કટારીયા શોરૂમ ની બાજુમાં	22.270493 - 70.743470	18-06-2024	19191.4272
8	Rajkot	Decora Sarovar	કાલાવડ રોડ, ઇસકોન મંદિર ની પાછડ	22.272531 - 70.731743	09-04-2024	55327.296
9	Rajkot	Universit y Dam	સૌરાષ્ટ્ર યુનિવર્સિટી કેમ્પસ	22.285683 - 70.745357	13-04-2024	72726.804
10	Rajkot	Palm Universal Sarovar	રૈયા રોડ, પામ યુનિવર્સલ ની સામે	22.297329 - 70.749109	09-05-2024	13435.584
11	Rajkot	Singada Sarovar	આકાશ પાર્ટી પ્લોટ ની પાછડ	22.262440 - 70.741651	21-07-2023	10232.136

Figure 28 Consent Letter- Vajdi Vad, Rajkot

Figure 29 Consent Letter- Todi, Bhavnagar

Details of Check-dam in Vajdi Vad

Sr. No.	Gaam/Taluka	Address	Coordinates	Commissioning Date	Capacity (in cubic meter)
1	Vajdi Vad	બાલાજી વેફરની નીચેના ભાગમાં રિપેરિંગ કરેલ	22.262946 - 70.700955	6/6/2022	2671.8768
2	Vajdi Vad	બાલાજી વેફરની બાજુમાં	22.273813 - 70.697023	6/10/2022	4742.688
3	Vajdi Vad	હીરાબા સરોવર	22.258439 - 70.701446	6/11/2022	2438.4
4	Vajdi Vad	હરીજન સ્મશાન પાસે	22.256506 - 70.696658	2/22/2023	886.0536
5	Vajdi Vad	કોડી સ્મશાન પાસે	22.254280 - 70.697455	2/22/2023	2511.2472
6	Vajdi Vad	દિલીપભાઇ ફૂલવાડા ની વાડીની બાજુમાં	22.261989 - 70.695647	7/2/2022	713.232
7	Vajdi Vad	દિલીપભાઇ ફૂલવાડા ની વાડીની બાજુમાં	22.262217 - 70.694773	9/30/2022	980.2368
8	Vajdi Vad	સંજયભાઇ ફૂલવાડા ની બાજુમાં	22.261739 - 70.693896	9/25/2022	632.7648
9	Vajdi Vad	પંચાયત ના કૂવા પાસે	22.261559 - 70.692796	9/29/2022	10308.336
10	Vajdi Vad	ઈશ્વરીયાના પાટીએ , કેનિક્સ હોટેલ ની બાજુમાં	22.261456 - 70.690834	9/11/2022	12193.524
11	Vajdi Vad	વગુડિયો નદી પાસે	22.263093 - 70.696358	9/10/2022	972.312
12	Vajdi Vad	બાલાજી વેફર્સની બાજુમાં	22.262614 - 70.696985	11/8/2022	2088.4896
13	Vajdi Vad	ગોપાલ વેફર્સ ની સામે	22.265511 - 70.693038	4/30/2023	5029.2
14	Vajdi Vad	હોટેલ કેનિક્સની બાજુમાં, ગામના પાદરે	22.260694 - 70.688653	5/8/2023	886.968
15	Vajdi Vad	ગોપાલ ફકટોરીની સામે	22.265579 - 70.694678	5/10/2023	2711.196
16	Vajdi Vad	ધોરિયા હોકર ડેમ ઉપર	22.261923 - 70.686809	5/12/2023	573.024
17	Vajdi Vad	ધોરિયા હોકર ડેમ ઉપર	22.260216 - 70.685591	5/13/2022	938.784

Details of Check-dam in Todi, Bhavnagar

Sr. No.	Gaam/Taluka	Address	Coordinates	Commissioning Date	Capacity (in cubic meter)
1	Todi, Bhavnagar	ગામની સ્કૂલ ની પાછડ	21.610972 - 71.870836	8/6/2022	1380.744
2	Todi, Bhavnagar	નિરુભા ની વાડીનો ચેકડેમ	21.611251 - 71.873709	8/6/2022	2132.3808
3	Todi, Bhavnagar	ગામના પાછડના પૂજારીના ઘરની બાજુમાં	21.610220 - 71.871437	8/7/2022	1005.84
4	Todi, Bhavnagar	અજયસિંહ ગોહીલની વાડી પાસે નું ચેકડેમ	21.615545 - 71.876455	9/10/2022	3227.832
5	Todi, Bhavnagar	ધમપાલી પાસે અવેરડા ની બાજુમાં ચેકડેમ	21.612453 - 71.865181	9/10/2022	1689.8112
6	Todi, Bhavnagar	ગામના પાદર નું ચેકડેમ	21.610291 - 71.871058	7/1/2022	738.8352
7	Todi, Bhavnagar	રણજીતસિંહ વાડી પાસે નું ચેકડેમ	21.612502 - 71.871500	9/15/2022	1783.08
8	Todi, Bhavnagar	ઇન્દ્રજીતસિંહ વાડી પાસે નું ચેકડેમ	21.614122 - 71.875595	8/13/2022	2369.82
9	Todi, Bhavnagar	નરેન્દ્રસિંહ વાડી પાસે નું ચેકડેમ	21.613057 - 71.873920	9/14/2022	1175.004
10	Todi, Bhavnagar	સુરુભા વાડી પાસે નું ચેકડેમ	21.608016 - 71.865865	8/11/2022	1258.2144
11	Todi, Bhavnagar	ધમપાલિની બાજુમાં ચેકડેમ	21.612308 - 71.865313	9/10/2022	1074.42
12	Todi, Bhavnagar	રબારી વિસ્તારની બાજુમાં ચેકડેમ	21.609546 - 71.866252	8/8/2022	1362.456
13	Todi, Bhavnagar	નીતુભા ની વાડી પાસેનો ચેકડેમ	21.611251 - 71.873709	8/10/2022	3127.248
14	Todi, Bhavnagar	ઊભી નદીવાળું ચેકડેમ	21.611490 - 71.876985	9/10/2022	1089.9648
15	Todi, Bhavnagar	ખરકડી ચેકડેમ	21.608074 - 71.865864	9/15/2022	1764.792
16	Todi, Bhavnagar	રૂપાભાઈના ઘર પાસે ચેકડેમ	21.609781 - 71.866514	8/11/2022	830.2752
17	Todi, Bhavnagar	પદુભાઈની વાડી પાસે ચેકડેમ	21.606945 - 71.869386	8/20/2022	1981.2
18	Todi, Bhavnagar	પ્રાવણસિંહ ની વાડી પાસે ચેકડેમ	21.602715 - 71.868848	9/20/2022	1943.1
19	Todi, Bhavnagar	ભીમભાઈ રબારી વાડી પાસે ચેકડેમ	21.613749 - 71.865874	8/15/2022	1305.7632
20	Todi, Bhavnagar	ભાયાભાઈ વાડી પાસે ચેકડેમ	21.615513 - 71.865669	8/15/2022	1322.832

Annexure II

Check Dams of Bhavnagar District

Check Dams of Rajkot District

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