



## CONTENTS

Executive Summary  
List of Tables  
List of Graphs  
List of Figures

Ch. No.	Title	Page No.
<b>Ch.1</b>	<b>INTRODUCTION</b>	<b>1 to 28</b>
	<b>1.1 Global Water Resources Endowment</b>	<b>1</b>
	<b>1.2 Water Resources of India</b>	<b>4</b>
	1.2.1 Water Resources Challenges in India	7
	1.2.2 Solutions to Challenges	8
	<b>1.3 Gujarat State</b>	<b>9</b>
	1.3.1 Geographical Details	9
	1.3.2 Physiography	10
	1.3.3 Topography	10
	1.3.4 Drainage	12
	1.3.5 Geohydrology	12
	1.3.6 Climate	14
	1.3.7 Rainfall	14
	1.3.8 Soils	15
	1.3.9 Water Resources in Gujarat	16
	1.3.10 Availability of Ground water resources	18
	1.3.11 Agriculture	18
	1.3.12 Water Quality in Gujarat State	19
	1.3.13 Reservoir Sedimentation in Gujarat	20
	1.3.14 Check Dams in Gujarat State	21
	1.3.15 Water Related Issues	22
	1.3.16 Solutions of Water Issues	23
	<b>1.4 Saurashtra Region</b>	<b>24</b>
	<b>1.5 Objective Of The Present Research Study</b>	<b>25</b>
<b>Ch.2</b>	<b>LITERATURE REVIEW</b>	<b>29 to 80</b>
	<b>2.1 World Scenario Of Artificial Recharge Of Ground Water</b>	<b>29</b>
	2.1.1 General	29
	2.1.2 EURO Survey on Artificial Recharge	30

	2.1.3 Other Work on Artificial Recharge in Europe	33
	2.1.4 Artificial Recharge in U. S. A.	35
	2.1.5 Artificial Recharge in Brazil	46
	2.1.6 Artificial Recharge in Australia	47
	2.1.7 Artificial Recharge in China	49
	2.1.8 Artificial Recharge in Japan	50
	2.1.9 Artificial Recharge in Oman	50
	2.1.10 Artificial Recharge in the Tropics	52
	<b>2.2 Artificial Recharge In India</b>	<b>53</b>
	2.2.1 General	53
	2.2.2 Semi - Arid Hard Rock Terrain in Western India	54
	2.2.3 South India (Andhra Pradesh)	57
	2.2.4 Alluvial Tract in North - West India	59
	<b>2.3 Artificial Recharge In Gujarat</b>	<b>62</b>
	2.3.1 Artificial recharge works taken up by Gujarat Government	62
	2.3.2 Artificial recharge works taken up by NGOs	62
	2.3.3 Evaluation Studies	66
	<b>2.4 Inferential Remarks</b>	<b>76</b>
<b>Ch.3</b>	<b>GENERAL DETAILS OF RAJKOT DISTRICT OF SAURASHTRA REGION - THE STUDY AREA</b>	<b>81 to 116</b>
	<b>3.1 Saurashtra Region</b>	<b>81</b>
	3.1.1 Geography	81
	3.1.2 Physiography	82
	3.1.3 Topography	82
	3.1.4 Drainage/ Rivers	82
	3.1.5 Geology/ Lithology	83
	3.1.6 Geohydrology	85
	3.1.7 Climate	86
	3.1.8 Rainfall	86
	3.1.9 Soils	88
	3.1.10 Surface Water Potential	88
	3.1.11 Ground Water Resources	91
	3.1.12 Agriculture	91
	3.1.13 Water Quality in Saurashtra District	93
	3.1.14 Salinity Ingress	93
	3.1.15 Domestic Water Supply	94
	3.1.16 Occurrence of Drought	94
	3.1.17 Check Dam : Rain water harvesting & Ground Water recharge Structures	96

	<b>3.2 Rajkot District</b>	<b>99</b>
	3.2.1 General Details	99
	3.2.2 Physiography	101
	3.2.3 Geology and Geohydrology	102
	3.2.4 Climate	106
	3.2.5 Agriculture	108
	<b>3.3 Bhadar River Basin</b>	<b>109</b>
	3.3.1 General	109
	3.3.2 Geohydrology	114
	3.3.3 Agriculture	115
	<b>3.4 Check Dams in Rajkot District</b>	<b>115</b>
<b>Ch.4</b>	<b>DATA COLLECTION FOR IMPACT OF CHECK DAMS ON BHADAR-I IRRIGATION PROJECT &amp; RAJKOT DISTRICT</b>	<b>117 to 160</b>
	<b>4.1 Baseline Data Collection</b>	<b>117</b>
	<b>4.2 Methodology-Used For Calculation Of Ground Water Resources Estimation</b>	<b>153</b>
	4.2.1 Assessment Year	154
	4.2.2 Unit Ground Water Recharge Assessment	155
	4.2.3 Delineation of Sub-area In The Unit	155
	4.2.4 Suitable Area	155
	4.2.5 Computation of Recharge for the Monsoon Season	155
	4.2.6 Recharge From Other Sources	155
	4.2.7 Total Annual Recharge	156
	4.2.8 Gross Ground Water Draft	156
	4.2.9 Irrigation Draft	156
<b>Ch.5</b>	<b>ANALYSIS &amp; IMPACT OF CHECK DAMS ON BHADAR-I MAJOR IRRIGATION PROJECT</b>	<b>161 to 235</b>
	<b>5.1 Salient Particulars of Bhadar Basin</b>	<b>161</b>
	5.1.1 Geographical Description	161
	5.1.2 Check Dams Related Details	164
	5.1.3 Analysis of rainfall-Runoff Formulas Adopted	180
	5.1.4 Analysis of Rainfall-Runoff Formulas on the Basis of Actual Observations	183
	5.1.5 Additional yield in Bhadar-I Without Check Dam Scenario	190
	5.1.6 Scenarios of Water Storage in Bhadar-I Reservoir Without Check Dam in Catchment	191

<b>5.2</b>	<b>Impact Of Checkdams In Sedimentation /Siltation In Bhadar Reservoir</b>	<b>204</b>
5.2.1	Trend of Sedimentation/Siltation in Various Regions	204
5.2.2	Sedimentation Survey Analysis of Bhadar Basin-I	207
5.2.3	Sedimentation/ Siltation in Check Dams	211
<b>5.3</b>	<b>Comparison Of Evaporation Losses In Bhadar Reservoir and Check Dams</b>	<b>213</b>
5.3.1	General	213
5.3.2	Evaporation Losses Considered in Bhadar Reservoir at the Time of Design	214
5.3.3	Actual Evaporation Losses of Bhadar-I dam Year 2002-03 to 2005-06	215
5.3.4	Evaporation Losses in Check Dams Constructed in Bhadar Reservoir	220
<b>5.4</b>	<b>Impact on Controlling Flood Routing of Bhadar Dam Due to Check Dams</b>	<b>225</b>
5.4.1	Bhadar Design Flood	225
5.4.2	Impact of Check Dams on Flood Routing June Year 2006	227
5.4.3	Impact of Check Dams on Flood Routing Year 2005	230
<b>5.5</b>	<b>Analysis of Ground Water Recharge in Bhadar Catchment Due to Check Dams</b>	<b>233</b>
<b>Ch.6</b>	<b>IMPACT OF CHECKDAMS ON GROUND WATER REGIME IN VARIOUS TALUKAS OF RAJKOT DISTRICT</b>	<b>236 to 276</b>
<b>6.1</b>	<b>Ground Water Assessment And Data Analysis</b>	<b>236</b>
6.1.1	Typical Analysis Of Ground Water Estimation Of Gondal Taluka	237
6.1.2	Analysis To Compare Rainfall Data Of All Talukas For Three Different Years Scenario	250
6.1.3	Checkdams	251
6.1.4	Water Table Fluctuation (WTF)	252
6.1.5	Monsoon Recharge	254
6.1.6	Total Ground Water Recharge	258
6.1.7	Total Ground Water Draft	261

	<b>6.2 Impact Of Checkdams In Ground Water Quality Of Various Talukas Of Rajkot District</b>	<b>265</b>
	6.2.1 General	265
	6.2.2 Total Dissolved Salts	267
	6.2.3 Impact Of Groundwater Recharge on Ground Water Quality	269
	<b>6.3 An Impact Of Check Dams On Cropping Pattern &amp; Agricultural Production In Rajkot District</b>	<b>272</b>
	6.3.1 Cropping Pattern in Rajkot District	272
	6.3.2 Water Availability and Crop Production in Rajkot District	274
<b>Ch.7</b>	<b>RESULTS, CONCLUSIONS AND RECOMMENDATIONS</b>	<b>277 to 306</b>
	<b>7.1 Impact Of Check dams On The Storage Of Bhadar Reservoir</b>	<b>277</b>
	7.1.1 Bhadar basin	277
	7.1.2 Bhadar I Irrigation scheme	278
	7.1.3 Additional Irrigation by Check Dams Water in Bhadar-I Command	279
	7.1.4 Abstract of additional Irrigation due to Check Dams Water in Bhadar-I Command	280
	<b>7.2 Impact of Check Dams On Sedimentation In Bhadar Reservoir</b>	<b>281</b>
	<b>7.3 Results Of Comparison Of Evaporation Losses In Check Dams With Bhadar Reservoir</b>	<b>283</b>
	7.3.1 Evaporation Losses in Checkdams	284
	<b>7.4 Flood Routing Of Bhadar Dam Due To Check Dams In Catchment</b>	<b>284</b>
	<b>7.5 Check Dams In Ground Water Recharge In The Catchment Of Bhadar Dam</b>	<b>287</b>
	<b>7.6 Impact Of Check Dams On Ground Water Regime Of Various Talukas Of Rajkot District</b>	<b>289</b>
	<b>7.7 Impact Of Check Dams In Increasing Crop Yield &amp; Production</b>	<b>294</b>
	<b>7.8 Ground Water Quality In Rajkot District (May-2006)</b>	<b>295</b>