## **LIST OF FIGURES**

Figure No.	DESCRIPTION	PAGE No.
2.1	Location of the Study Area	9
2.2	Kim River Watershed and its Communication Network	12
3.1	Tectonic Trends of North Western India (Biswas, 1987)	18
3.2	Geological Map of South Gujarat	20
3.3	Geological Setup of Kim River Basin	21
3.4	Sediment Succession of Floodplain Deposits Exposed Along the Kim River Channel	24
4.1	Physiographic Divisions of the Kim Watershed Region	28
4.2	Landforms in the Kim-Tapi Block	30
4.3	Kim Drainage Network	40
4.4	Supervised Classification of Land-use Pattern, Kim River Basin (1998)	42
4.5	Supervised Classification of Land-use Pattern, Kim River Basin (2003)	42
4.6	Supervised Classification of Land-use Pattern, Kim River Basin (2008)	43
4.7	Supervised Classification of Land-use Pattern, Kim River Basin (2013)	43
5.1	Soil Map of Gujarat (After, NWRWS, Govt. of Gujarat, 2010)	48
5.2	Textural Classification of Soils (USDA, 1970)	51
5.3	Particle Size Distribution Curves for Different Soil Types in the Study Area	52
5.4	Soil Map of Kim River Watershed	54
5.5	Range of Soil pH across the Kim River Basin	64
5.6	Electrical Conductivity vis-à-vis Soil Types in the Kim River Basin	65
5.7	Observed Range of Organic Carbon Percentage in Various Soil Types of the Kim River Basin	66
5.8	Range of CEC available in of Various Soil Types of Kim River Basin	69
5.9	Observed Base Saturation of Basic Soil Cations Found in Kim River Basin	70
6.1	Theissen's Polygon Method applied over the Kim River Basin	76
6.2	Rainfall Time Series Curve for the Study Area (1983-2013)	77
6.3	A Schematic Cross Section of Village Pond Giving Details on Saline Water Interface and Creation of Potable Groundwater Mound along	81

## with Open Dug Wells for Groundwater Abstraction.

6.4	Map Showing Network of Various Branch and Distributary Canals in the Study Area	85
6.5	Annual Discharge Hydrograph of Kim River as Observed at Daheli	87
7.1	Network of Observation Wells in the Kim River Basin	95
7.2a	Reduced Water level Contour Map of the Kim River Basin (Pre-monsoon, 2013)	101
7.2b	Reduced Water level Contour Map of the Kim River Basin (Post-monsoon, 2013)	101
7.3	Seasonal Net change in Groundwater Storage (2013)	102
7.4	Well Hydrographs Showing Secular Behaviour of Groundwater Table of Selected Observation Wells in the Study Area	105
7.5	Secular Changes in the Groundwater Storage in the Study Area (1998 -2013)	108
7.6	Hydro-isobath of TDS (mg/l) in the Central and Lower Parts of the Study Area (Pre-monsoon 1998)	109
7.7	Hydro-isobath of TDS (mg/l) in the Central and Lower Parts of the Study Area (Pre-monsoon 1998)	109
7.8	Hydro-isobath Map of Central & Lower Parts of the Study Area (Pre-monsoon 1998)	113
7.9	Hydro-isobath Map of Central & Lower Parts of the Study Area (Pre-monsoon 2003)	113
7.10	Hydro-isobath Map of Central & Lower Parts of the Study Area (Pre-monsoon 2008)	114
7.11	Hydro-isobath Map of Central & Lower Parts of the Study Area (Pre-monsoon 2013)	114
7.12	Iso- TDS Contour Map of Kim River Basin (Pre-monsoon 2013)	125
7.13	Iso- TDS Contour Map of Kim River Basin (Post-monsoon 2013)	125
7.14	US Salinity Chart for Classification of Irrigation Water (After Richards, 1954)	130
7.15	Wilcox Diagram for Sodium Percentage (After Wilcox,1955)	131
8.1	The Green and Blue Water Footprints of a River Basin	140
8.2	Comparative Display of Water Consumption and Wastewater Generation in the Industrial Sector of the Kim River Basin	145
8.3	A Comparative Chart Depicting the Changing Scenarios of EC and EF in the Kim River Basin (1998-2013)	158

## **LIST OF PLATES**

Plate No.	DESCRIPTION	PAGE No.
3.1	A Close View of Basalt Quarry in the Kim River Basin	22
3.2	A View of Outcrops of Fossiliferous Limestone (Loc. Dinod)	23
4.1	Space View of the Physiography of the Study Area	28
4.2	Kim Mudflats (low marsh) with Mangrove Forest	31
4.3	Ripple Marks- A Fluviatile Current Imprints in Sand	32
4.4	Mouth Bar of Kim River as Seen from Satellite Imagery	32
4.5	A View of Kim River Meander showing Development of Point Bar-Mid-channel Bar and Terrace	34
4.6	Mid-Channel Bar Deposits. (Loc. U/S Kim-Vadoli Highway Bridge)	34
4.7	Satellite View of the Present Day Meandering Loops and Paleo-channels of the Kim River in the Alluvium and Coastal Plains	35
4.8	Satellite Imageries Showing Modification of Kim River Drainage (From 1984 to 2014)	36
4.9	Satellite View of Pediment Zone Around Basalt Ridges	37
4.10	A view of local Knick Point Developed due to some local tectonic factor	38
4.11	Cropping Out of Bed-rock Creating Water Pool and Fall in the River Channel	38
5.1a	Field Photo Depicting process of Augering for Soil Sampling	48
5.1b	Collection of Soil Sample and Preservation	48
5.2	A Field View of Poorly Drained Coastal Alluvial Soil	56
5.3	A Field View of Black Clayey Soil (Loc. Kadrali, Tal. Mangrol)	58
5.4	A Field View of Loamy Brown Soil Adjacent to the Pediment Zone	59
6.1	A view of Village Pond Inhibiting Open dug Well at the Peripheral Region.	82
6.2	A View of Pingut Dam and Reservoir	83
6.3	A View of unlined Warethi Distributary of the URBC	85
6.4	Pollution in the Kim River due to Domestic Activities.	88
7.1	A Satellite View of Hydrofractures in the Upper Parts of the Study Area	97
7.2	Groundwater oozing out under hydraulic pressure from Hydrofractures in a basaltic aquifer	97
7.3a	A View of Open Dug well showing Near Groundwater Table within the Basaltic aquifer	98
7.3b	A View of a Lined Open Dug well of Free Flowing Nature developed within Weathered Basaltic Aquifer in a Pediment Zone	98
7.4	A view of an Open Dug well in Limestone Aquifer with a Profused  Groundwater Yield	99

## **LIST OF TABLES**

Table No.	DESCRIPTION	PAGE No.
3.1	Litho-stratigraphy of the Kim River Watershed and Its Environs	20
4.1	Landforms Identified in the Kim River Basin	28
4.2	Quantitative Assessment on Change in Land-use Categories in the Kim River Basin (1998-2013)	44
5.1	Index of Standard Methods Adopted for Soil Analysis	50
5.2	Particle Size Distribution of Different Soils of the Kim River Basin	53
5.3	Textural Characteristics of Identified Soils in the Kim River Basin	55
5.4	Physico-chemical Parameters of Coastal Alluvial Soils	56
5.5	Physico-chemical Parameters of Clayey Black (Cotton) Soils	58
5.6	Physico-chemical Parameters of Brown Loamy Soils	60
5.7	Physico-chemical Parameters of Mixed Soils occurring in the Kim River Basin	61
5.8	Chemical Characteristics of Red/Laterite Soils in the Kim River Basin	62
5.9	Chemical Constituents of Different Soil Types of the Kim River Basin	63
5.10	Salinity Classes of Soils based on Electrical Conductivity	65
5.11	A Generalized Correlation between Soil Texture and CEC	69
6.1	Observed Average Monthly Temperatures, Relative Humidity and Wind records in the Kim River Basin	74
6.2	Weighted Precipitation for Kim River Basin by Theissen's Method	77
6.3	Decadal Average (2003-2013) Climatic Parameters in the Kim River Basin	79
6.4	Decadal change in Various Water Sources for Irrigation in the Study Area	80
6.5	Salient Features of the Baldeva and Pingut Irrigation Schemes in the Study Area	83
6.6	Decadal Status of Hydrologic Storage and Irrigation Inputs of Pingut and Baldeva Irrigation Schemes	84
6.7	A Summary of Annual Discharge of Kim River as Monitored at Daheli	86
6.8	Kim Water Quality as monitored in the U/S and D/S of the river	88
6.9	Binnie's Annual Runoff Percentages	89
6.10(A)	Percentage Coefficients (k) for Surface Runoff Computation	90
6.10 (B)	Table 6.10(B) Annual Surface Runoff for the Kim Watershed	91
7.1	Secular Net Change in Static Water Levels (1998 and 2013)	107

7.2	Quantitative Assessment of hydro- isobaths of TDS in the Middle and Lower	110
7.3	Classification of Water Logged Areas (FAO,1970)	111
7.4	Status of Cropping Pattern in URBC	112
7.5	Hydro-Iso-Bath Estimates of central and lower Parts of the Kim River Basin	115
7.6	Groundwater Recharge Estimation for the Kim River Basin	117
7.7	Seasonal Chemical Composition of Groundwater ( 2012)	120
7.8	Seasonal Chemical Composition of Groundwater (2013)	121
7.9	Seasonal Behaviour of Groundwater Chemistry in the Kim Basin	122
7.10	Aquifer Specific Seasonal Trends in Groundwater Chemistry	122
7.11	Seasonal Level of Irrigation Water Quality Indices	128
7.12a	Salinity hazard classification on the basis of EC Values	129
7.12b	Sodium Hazard Classification on the Basis of SAR Values	129
7.13	Classification of Irrigation Water Based on Soluble Sodium Percentage	132
8.1	Domestic Water Footprint of the Kim River Basin (1998-2013)	143
8.2	Industrial Water Footprint of the Kim River Basin (1998-2013)	144
8.3	Summary of Livestock Population in the Kim River Basin (1998-2013)	146
8.4	Livestock Water Footprint of the Kim River Basin (1998-2013)	146
8.5	Status of Blue Green Components of the Kim River Basin (1998-2013)	149
8.6	Status of Green Water Components of the Kim River Basin (1998-2013)	150
8.7	Water Footprint of Forest Cover in the Kim River Basin (1998-2013)	151
8.8	Water Footprint of the Kim River Basin	152
8.9	Ecological Footprint Summary of the Kim River Basin (1998-2013)	158
9.1	Water Balance of the Kim River Basin (1998-2013)	162