



## LIST OF FIGURES

|                                                                                                                                                                                    | Page |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>Fig.1.1:</b> Location map of the Study area.                                                                                                                                    | 5    |
| <b>Fig.1.2:</b> Geological map of the area around Kachchh Mainland Fault.                                                                                                          | 6    |
| <b>Fig.1.3:</b> Map showing major physiographic divisions, isohyets and climatic zones of Gujarat (after Singh et al., 1991 and Department of Agriculture, Government of Gujarat). | 7    |
| <b>Fig.1.4:</b> Graph showing average month wise rainfall in Kachchh district.                                                                                                     | 8    |
| <b>Fig.1.5:</b> Graph showing average month wise temperature in Kachchh district.                                                                                                  | 8    |
| <b>Fig.1.6:</b> DEM of Gujarat showing general physiography of Gujarat and Kachchh region.                                                                                         | 10   |
| <b>Fig.1.7:</b> SRTM generated contour map of the area showing topography.                                                                                                         | 10   |
| <b>Fig.1.8:</b> DEM of the area around the eastern part of Kachchh Mainland Fault.                                                                                                 | 11   |
| <b>Fig.1.9:</b> DEM of Khadir Island (height exaggerated).                                                                                                                         | 11   |
| <b>Fig. 2.1:</b> Geological map of Kachchh District (modified after GSI, 2001).                                                                                                    | 18   |
| <b>Fig. 2.2:</b> Tectonic map of Kachchh region (modified after Biswas and Deshpande, 1970).                                                                                       | 27   |
| <b>Fig.2.3:</b> Major Faults of the Kachchh draped over the DEM of the area.                                                                                                       | 28   |
| <b>Fig.2.4:</b> Bouguer Anomaly map of Kachchh region (after GSI, 2001).                                                                                                           | 28   |
| <b>Fig.2.5:</b> Geological Cross Section across Kachchh basin along the Median High (modified after Biswas, 2005).                                                                 | 29   |
| <b>Fig.2.6:</b> Elevation profile across Saurashtra-Nagar Parkar (generated from SRTM data).                                                                                       | 29   |
| <b>Fig.2.7:</b> Correlation of major faults of Kachchh with the elevation profile of the area.                                                                                     | 30   |
| <b>Fig.2.8:</b> Spatial distribution of the dykes and faults in the Kachchh region.                                                                                                | 31   |
| <b>Fig.2.9:</b> Rose diagram showing the orientation of the dykes in Kachchh.                                                                                                      | 32   |
| <b>Fig.2.10:</b> Rose diagram showing orientation of faults of Kachchh region.                                                                                                     | 33   |

|                  |                                                                                                                                                                                        |    |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Fig.2.11:</b> | Gravity section across KMF (between Nokhania-Bherandiyara) and inferred geological model (after Singh and Lal, 2008).                                                                  | 34 |
| <b>Fig.3.1:</b>  | Geomorphological map of Kachchh Peninsula.                                                                                                                                             | 38 |
| <b>Fig.3.2:</b>  | DEM of the Kachchh Peninsula depicting the geomorphic units.                                                                                                                           | 39 |
| <b>Fig.3.3:</b>  | Topographic profile showing the general Physiography of the Kachchh region.                                                                                                            | 39 |
| <b>Fig.3.4:</b>  | Distribution of land and water with increase in the sea level, showing general topographic model of the Kachchh Peninsula. The rise of sea level is indicated in the each figure in m. | 43 |
| <b>Fig.3.5:</b>  | Drainage map of the Mainland Kachchh.                                                                                                                                                  | 45 |
| <b>Fig.3.6:</b>  | ETM FCC image of the Mainland Kachchh showing major geomorphic units and drainage around Kachchh Mainland Fault.                                                                       | 46 |
| <b>Fig.3.7:</b>  | Detailed drainage map of the area along Kachchh Mainland Fault.                                                                                                                        | 47 |
| <b>Fig.3.8:</b>  | Longitudinal profile of the Kaswali River.                                                                                                                                             | 48 |
| <b>Fig.3.9:</b>  | Fluvial terrace sequence exposed along the Dhrung River.                                                                                                                               | 49 |
| <b>Fig.3.10:</b> | Fluvial terrace sequence exposed along the Kaswali River, near Lodai village.                                                                                                          | 49 |
| <b>Fig.3.11:</b> | Litholog of a trench in the Recent alluvial deposit, north of Khirsara village.                                                                                                        | 50 |
| <b>Fig.3.12:</b> | Litholog of the Dhrung River Section, near Dhrung Dam.                                                                                                                                 | 50 |
| <b>Fig.3.13:</b> | Litholog of the Dhrung River Section, near Dhrung Dam with corresponding section in the photograph.                                                                                    | 50 |
| <b>Fig.3.14:</b> | Upstream view of the Dhrung River, near Dhrung Dam.                                                                                                                                    | 51 |
| <b>Fig.3.15:</b> | Longitudinal profile of the Pur River.                                                                                                                                                 | 51 |
| <b>Fig.3.16:</b> | Longitudinal profile of the Kaila River.                                                                                                                                               | 52 |
| <b>Fig.3.17:</b> | Longitudinal profile of the Nirona River.                                                                                                                                              | 52 |
| <b>Fig.3.18:</b> | Valley cross section of the Nirona River, away from mouth, showing terraces.                                                                                                           | 52 |
| <b>Fig.4.1:</b>  | LISS-III FCC imagery of Kaswali River basin and detailed drainage map of the basin showing different order of streams.                                                                 | 60 |

|                  |                                                                                                                                                                       |    |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Fig.4.2:</b>  | ETM Landsat FCC imagery (234) of the Pur River basin and detailed drainage map of the basin showing different order of streams.                                       | 62 |
| <b>Fig.4.3:</b>  | LISS-III FCC imagery of Kaila River basin and detailed drainage map of the basin showing different order of streams.                                                  | 64 |
| <b>Fig.4.4:</b>  | LISS-III FCC imagery of Nirona River basin and detailed drainage map of the basin showing different order of streams.                                                 | 66 |
| <b>Fig.4.5:</b>  | ETM Landsat FCC imagery (234) of Chhari River basin and detailed drainage map of the basin showing different order of streams.                                        | 68 |
| <b>Fig.4.6:</b>  | Regression log of Stream numbers versus Stream order.                                                                                                                 | 70 |
| <b>Fig.4.7:</b>  | Drainage map of the area along Kachchh Mainland Fault showing deflection of the streams towards west.                                                                 | 73 |
| <b>Fig.4.8:</b>  | River basins with their main trunks and left and right tributaries showing basin asymmetry.                                                                           | 74 |
| <b>Fig.4.9:</b>  | Longitudinal profile of the Kaswali River with Vf values and valley cross section. Near the source cross section is V-shaped whereas away from source it is U-shaped. | 76 |
| <b>Fig.4.10:</b> | Longitudinal profile of the Khari stream of the Pur River with Vf values and valley cross section.                                                                    | 77 |
| <b>Fig.4.11:</b> | Longitudinal profile of the Pat stream of the Pur River with Vf value and valley cross section.                                                                       | 77 |
| <b>Fig.4.12:</b> | Longitudinal profile of the Pur River with Vf value and valley cross section.                                                                                         | 78 |
| <b>Fig.4.13:</b> | Longitudinal profile of the Kaila River with Vf value and valley cross section.                                                                                       | 78 |
| <b>Fig.4.14:</b> | Longitudinal profile of the Nirona River with Vf value and valley cross section.                                                                                      | 79 |
| <b>Fig.4.15:</b> | Longitudinal profile of the Chhari River showing gradient in sectors.                                                                                                 | 79 |
| <b>Fig.4.16:</b> | Longitudinal profile of Kaswali River showing Ap and Ar for PHI                                                                                                       |    |

|                  |                                                                                                                                |     |
|------------------|--------------------------------------------------------------------------------------------------------------------------------|-----|
|                  | calculation.                                                                                                                   | 81  |
| <b>Fig.4.17:</b> | Location of mountain fronts selected for Sinuosity Index calculation.                                                          | 83  |
| <b>Fig.4.18:</b> | Segments of the Kaswali River used for calculation of river sinuosity.                                                         | 85  |
| <b>Fig.4.19:</b> | Segments of the Nirona River used for calculation of river sinuosity.                                                          | 87  |
| <b>Fig.5.1:</b>  | Normal fault in the Bhuj Formation.                                                                                            | 90  |
| <b>Fig.5.2:</b>  | Convolute Lamination in Bhuj Sandstones, Pur River section, Rudramata.                                                         | 90  |
| <b>Fig.5.3:</b>  | Liquefaction induced structure in the Bhuj Formation. Note the mud is intruding into sand layer; Pur River Section, Rudramata. | 91  |
| <b>Fig.5.4:</b>  | Ball and Pillow structure in the Bhuj sandstone; Pur River section, Rudramata.                                                 | 91  |
| <b>Fig.5.5:</b>  | Sand dykes cutting across the litho-units of the Mesozoic sequence, south of Jawaharnagar.                                     | 91  |
| <b>Fig.5.6:</b>  | Seismic Zones in India (prepared by Bureau of Indian Standard).                                                                | 93  |
| <b>Fig.5.7:</b>  | Earthquake records of Kachchh region from historic times through 2010 (Source: IRS, 2010).                                     | 95  |
| <b>Fig.5.8:</b>  | Allah Bund Fault, over Google image, visible in the ASTER DEM and field photograph (north of Dharmshala).                      | 96  |
| <b>Fig.5.9:</b>  | Map showing the Iseismals of 2001 Bhuj Earthquake and the epicenters of the aftershocks in 2001.                               | 98  |
| <b>Fig.5.10:</b> | Drag fold in the gypseous shale of Miocene age, North of Khirsara village.                                                     | 101 |
| <b>Fig.5.11:</b> | Schematic diagrams showing stream deflection at KMF, north of Devisar.                                                         | 102 |
| <b>Fig.5.12:</b> | Contorted laminations in sandy horizons to the north of Khirsara village.                                                      | 102 |
| <b>Fig.5.13:</b> | Contorted laminations in the miliolitic limestone, south-west of Dhrung.                                                       | 103 |

|                  |                                                                                                                                                                                                                                                                                                                                                |     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Fig.5.14:</b> | Fault in miliolitic limestone of Pleistocene age, south-west of Dhrung.                                                                                                                                                                                                                                                                        | 103 |
| <b>Fig.5.15:</b> | Manfara transverse fault visible as coseismic ground fissures due to Bhuj (2001) earthquake.                                                                                                                                                                                                                                                   | 105 |
| <b>Fig.5.16:</b> | Litholog of the trench made across the Manfara Fault, near Kharoi.                                                                                                                                                                                                                                                                             | 106 |
| <b>Fig.5.17:</b> | LISS-III imagery of alluvial fan of the Pur River showing lineament, which proved to be an active fault. The lower imagery is the enhanced one by Principal Component Analysis method and fault is better viewed in this imagery. Coseismic ground fissures (due to Bhuj earthquake), developed along the Loriya Fault are shown to the right. | 108 |
| <b>Fig.5.18:</b> | DEM of alluvial fan of Pur River (left) and asymmetrical profile indicating the effect of Loriya fault (right). X-Y is the section line for profile.                                                                                                                                                                                           | 109 |
| <b>Fig.5.19:</b> | Geophysical profile across the Loriya active fault, signatures of gravity and magnetic anomaly is detected on the fault (after Singh and Lal, 2008).                                                                                                                                                                                           | 109 |
| <b>Fig.5.20:</b> | Pre- and post- Bhuj earthquake images showing the liquefaction centers.                                                                                                                                                                                                                                                                        | 110 |
| <b>Fig.5.21:</b> | View of the eastern terrace of the Dhrung River, near Dam showing a Quaternary reverse fault.                                                                                                                                                                                                                                                  | 112 |
| <b>Fig.5.22:</b> | Budharmora upwarp (developed due to Bhuj earthquake) and a schematic diagram of the trench across.                                                                                                                                                                                                                                             | 113 |
| <b>Fig.5.23:</b> | Emergence of buried channels, north of Amrapar.                                                                                                                                                                                                                                                                                                | 114 |
| <b>Fig.5.24:</b> | Oozing of water in the channels in the marshy region of Rann of Kachchh (Pre-Bhuj earthquake imagery to the left and post earthquake imagery to the right).                                                                                                                                                                                    | 114 |
| <b>Fig.5.25:</b> | Lodai Transverse Fault.                                                                                                                                                                                                                                                                                                                        | 115 |
| <b>Fig.5.26:</b> | Dhrung Transverse Fault.                                                                                                                                                                                                                                                                                                                       | 115 |

|                  |                                                                                                                          |     |
|------------------|--------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Fig.5.27</b>  | A- Distant view and B- close view of transverse faults cutting the Jara dome in the SW of Lakhpat.                       | 115 |
| <b>Fig.5.28:</b> | Neotectonic map of the area along KMF between Loriya and Manfara faults.                                                 | 115 |
| <b>Fig.6.1:</b>  | Evolution of Kachchh Mainland in relation to KMF.                                                                        | 121 |
| <b>Fig.6.2:</b>  | Tertiary polymictic conglomerate overlying the Bhuj sandstone, Amardi village.                                           | 123 |
| <b>Fig.6.3:</b>  | Digital Elevation Model of the Kachchh showing the transverse faults to the KMF and their inferred strike slip movement. | 124 |
| <b>Fig.6.4:</b>  | Devisar Transverse Fault.                                                                                                | 125 |
| <b>Fig.6.5:</b>  | Amrapar (Dudhai) Transverse Fault.                                                                                       | 125 |
| <b>Fig.6.6:</b>  | Transverse fault to the east of Lakhpat.                                                                                 | 125 |
| <b>Fig.6.7:</b>  | Transverse fault across the Jara dome.                                                                                   | 125 |
| <b>Fig.6.8:</b>  | Strike-slip movement along the Lodai, Pur and Kaila transverse faults visible on the DEM of the area along KMF.          | 126 |