

**A REMOTE SENSING ANALYSIS OF THE RECENT
EARTHQUAKE : BHUJ AND KATHIAWAR PENINSULA
OF THE INDIAN SUB - CONTINENT TO SEGREGATE INTO ISLAND**

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ABSTRACT:- The present study is an attempt to use remote sensing technique for surfacial changes in the Bhuj-Kachchh and Kathiwar-Saurashtra areas. The whole investigation has been carried through visual interpretation technique. The pre and post earthquake satellite picture reveals that fault zones have been developed right from the Greater Rann to the little Rann. The Kachchh main land fault has been intensified. So far this region has experienced nearly 2500 earthquake shocks from low to high intensity since 20th January 2001. If this region continues to experience earthquakes quite frequently, the peninsula of Kachchh-Bhuj and Kathiwar-Saurashtra will be cut off from the main land of Gujarat as a result of new tectonic and mountain building activity in the next few thousands years. It could also take the shape of two separate islands. Now it is the area of severe active seismic zone of the world.

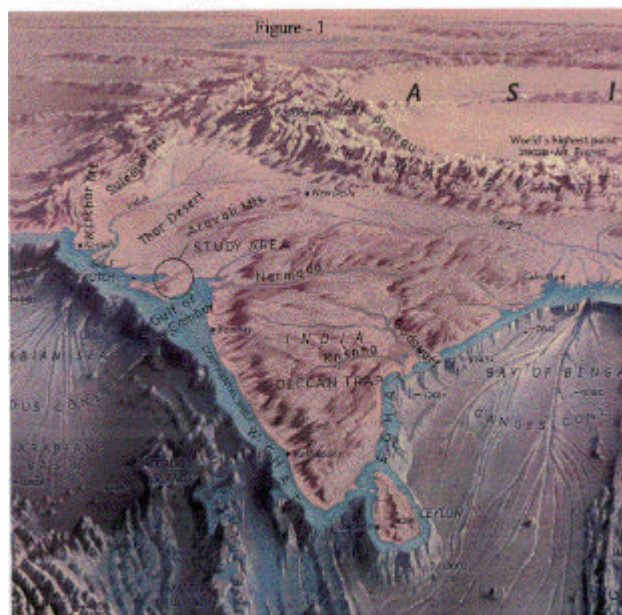
STUDY AREA

The present study area (Figure-1) lies between 20°30' north to 24°30' north latitudes and 69° east to 73° east longitudes. Geographically this region is the part of semi-arid to sub-tropical of western India in the Indian sub-continent. The Tropic of cancer divides Kachchh-Bhuj into two parts. The Geological evolution of Kachchh and Kathiwar began with the breaking up the Gondwanaland. Its subsequent geological history is related to the northward drift of the Indian sub-continent and breaking up of the western continental margin.

The coast of Kachchh, both on the west and on the south, is surrounded by 10-13 km wide marshy zone. There are innumerable creeks dotting the coastline in Kuchchh. The Gulf of Kachchh (7,350 Sq. Km) is aligned in an east-west orientation. Its depth extends from less than 20 m at the head (eastern end) to about 60 m at the mouth (western end).

The Gulf of Khambhat (3,120 Sq. Km) is aligned in a north-south orientation. It is marked by huge interaction of saline and fresh waters, providing it the characteristics of an extended estuarine system. The eastern fringe of Kathiwar -Saurashtra is a low lying ground marking the site of the former sea connection between the Gulf of Kachchh and Khambhat.

Relief Map of Indian Sub-Continent



MATERIAL AND METHOD

In this study IRS WiFS and IRS I D LISS III Remote Sensing Satellite data i.e. different dates in black and white and colour composites with the help of computer were used for visual interpretation. The false colour composite RS data of 1 : 250,000 was brought on 1 : 100,000 scale to make the study comprehensive. With the help of digital analysis the zoomed four site of pre and post earthquake was analysed by visual interpretation technique. Indian topographical sheets and maps were also used for study purpose. For the visual interpretation the remotely sensed data and ground truth data have been collected from the field. Apart from the data inferred from the satellite images, digital data, topographical maps and field survey, the relevant data were also collected from secondary sources.

DISCUSSION

Five thousand years ago the well developed civilizations of Indus, Ahar and Harrappa were destroyed by the earthquakes and cyclones. The area between the Aravalli and Biluchistan was drained by various rivers and it was a very fertile plain. Due to the tectonic activity, the Nagour region got uplifted and an upland was developed. At the same time this region got converted into a desert area and this became the cause of the disappearance of the mythical river Saraswati. Owing to the tectonic activities the Banganga river which was flowing on the eastern side of the Aravallis got converted into inland drainage system near Bharatpur in eastern Rajasthan. Around the same time, certain tectonic activity took place near Mathura causing the upliftment of Govardhan mountain. The people of this region relate this event with the legend of lord Krishna who raised Govardhan mountain on the tip of his finger to save the Braj people from the effect of terrible floods.

In the Vedic period the area between Saraswati and Yamuna river faced the tectonic activity. The mouth of Banganga river got converted into depression and nowadays that depression is famous the world over as a Ghana Bird's Sanctuary. On the basis of the above mentioned evidence it can be said that this region will face the tectonic activity in future also.

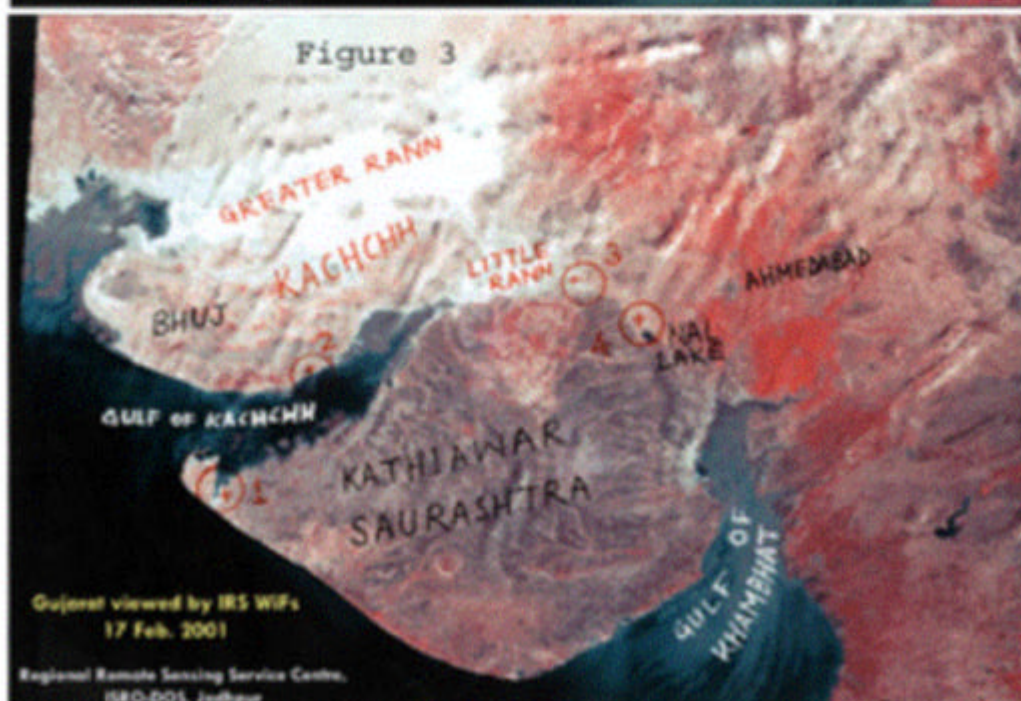
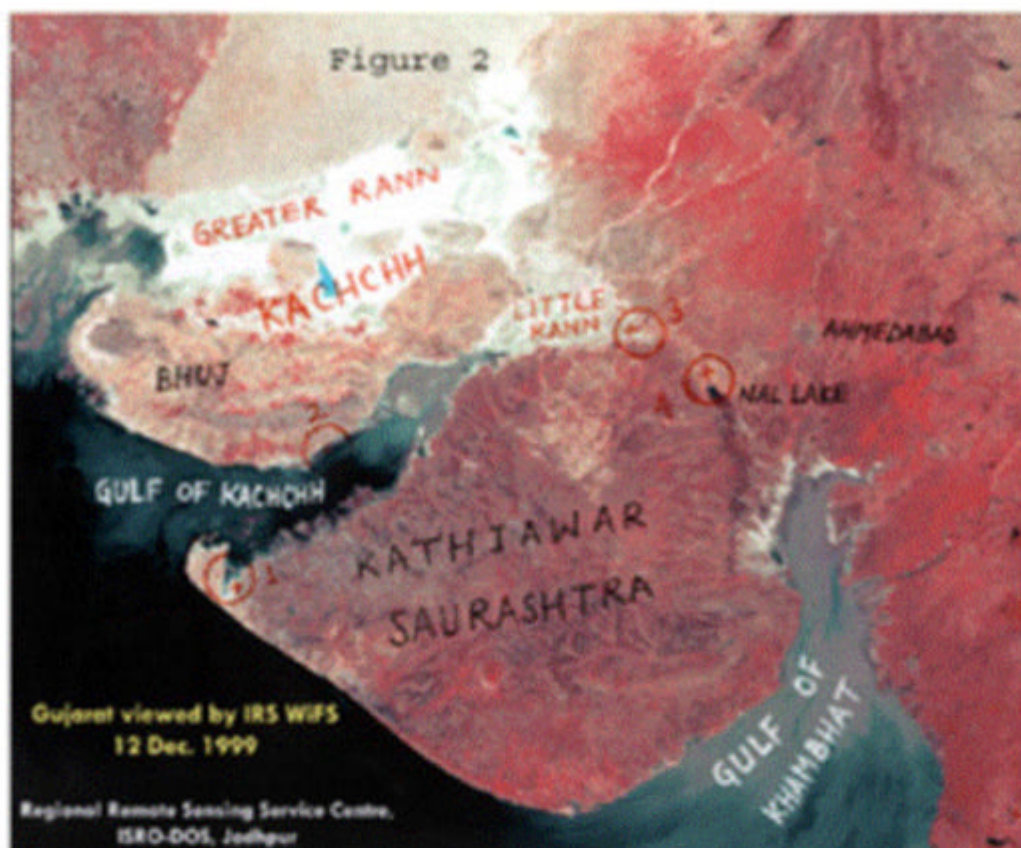
During the Vedic times the well developed civilizations of Ahar, Indus and Makaran etc. extended upto an area of 20 lakh Sq. Km. with Yamuna river in the east, Jammu to Hindukush mountain in the north, upto Makaran coast in the west situated near Pakistan-Iran border; it also included the Gulf of Khambhat in the south upto Aravalli..

Five thousand years ago the area between Aravalli mountain region of India and Baluchistan mountain region of Pakistan acted as one geographical unit which was highly populated, very fertile and was the region of well developed civilizations of the world. In this region the drainage pattern and climatic conditions were similar to the present climate and drainage system between Chotanagpur plateaus of eastern India and Arakan Yama mountain region of Myanmar. After that the high rainfall belt of Northwest India got shifted towards the present eastern India.

During the Vedic period earthquakes, cyclones and heavy rains occurred in Kachchh, Indus, Shekhawati and Brij regions. Due to this Lothal of Khambhat, Ahar of South Aravalli, Kalibanga of Hanumangarh, Banwali of Hissar, Siwaliks of Himalayas and Harrappa - Mohan-Jodharo and Sutkagedore etc. of the well developed civilizations were destroyed. Due to frequent occurrence of tectonic activity and cyclones which came from the Arabian sea, changes in the climate, heavy population pressure and scarcity of natural resources, the well developed civilized people of this region migrated towards Central Asia, Asia-Minor, Middle-East, Balkan region, Coastal region of the Mediterranean sea and Tibet.

ANALYSIS

The Killer earthquake on 26th January, 2001, the 51st Republic Day of India was accompanied by large scale changes in surface and coastal features. The high revisit capabilities of IRS WiFS images have been helpful in this study. One IRS image prior to the earthquake was analyzed along with post earthquake images of the area to arrive at meaningful conclusion, regarding surfacial changes in Bhuj-Kachchh and Kathiawar-Saurashtra regions. WiFS images are also useful to study synoptic contiguity of topographical changes due to their larger swath as compared to LISS-III images. Figure 2 and 3 shows the series of WiFS images of a number of dates both before and after the earthquake (namely Dec., 12, 1999 and Feb. 17, 2001 Figure 1&2) for one of the four test sites as is shown in Figure 4. All the images are two band false colour composite with B 4 (near infra red) band.



The above figures show WIFS FCC images of 12th Dec. 1999 & 17th Feb. 2001 depicting the location of sites used for detailed analysis.

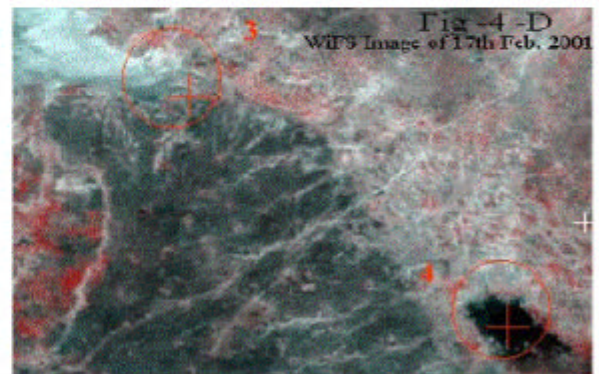
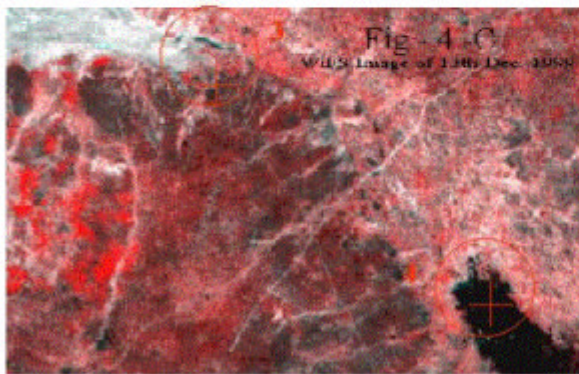
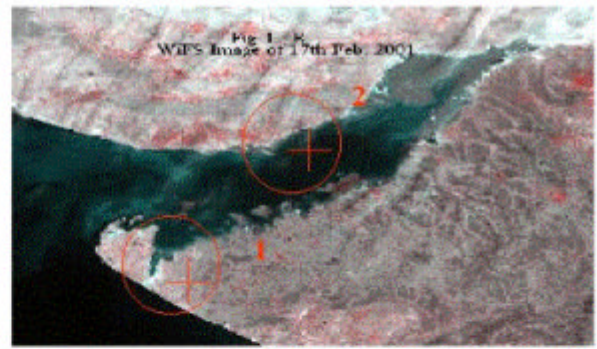
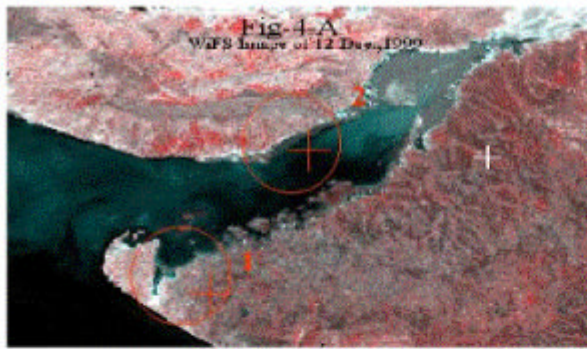


Figure 4-A & C show Images of Dec. 12th, 1999, one year before the earthquake.

Figure 4-B & D show Images of Feb. 17th, 2001. These Images show the change of surface among all analyzed WiFS Images Red + in circles indicating changes in features.

The intense shaking brought out changes in the ocean and land surface and sub-surface. At numerous places in Kachchh, emergence of water on the earth's surface was observed. Near Rapar after earthquake craters-like structure emerged. Near these craters, 500 meter long cracks with orientation Eastwest and Northwest and Southwest were seen. The visual interpretation of WiFS data for two dates, one prior (12 Dec. 1999) and after (17th Feb., 2001) earthquake were analysed and suspended solid were deduced. The comparison of pre (Figures -2, 4-A & 4-C) and post (Figures -3, 4-B & 4-D) images of earthquake shows drastic changes in cracks of the Gulf of Kachchh, little Rann, and near Nal lake. The surface features were extracted from satellite images and tectonic lineaments were extracted. The earthquake image of February 17, 2001 shows significant surface manifestation in the study area. The comparison of Figures- 2 and 3 reveal that the significant surface changes clearly observed from the post images (Figure 3 and 4-B & D). The pre and post earthquake remotely sensed data reveals that new fault zones have been developed right from the Greater Rann to Little Rann and Kachchh main land fault has been intensified. New faults, folds, and joints were observed near Anjar, Bhuj, Bachan, Chapat, Kandla, Naliya, Pachham, Khadir, Bela, Jamnagar, Okha, Dwarka, Surendranagar, Navtakhi, Morbi, Kuda and Adhoi.

The same significant surficial changes were also observed between little Rann to Nal lake and Nal lake to Gulf of Khambhat. It not only caved in the surface level but at many places lava, hot water, water channel and surges have come out from the bowels of the earth. The detailed analysis of multisensors and multirate data are underway. The combination of low and high resolution remote sensing data is likely to throw information related to the changes in coastal area and land surface. The integration of these information through Geographical information system is likely to give some clues in understanding this unique type of earthquake.

RESULTS

So far this region has experienced nearly 2500 earthquake shocks from low to high intensity since 26 January, 2001. If this region continues to experience earthquake quite frequently the peninsula of Bhuj-Kachchh and Kathiawar-Saurashtra will be cut off from the main land of Gujarat as a result of new tectonic activities in the next few thousand years. It could also take the shape of separate island. This will further result in the union of the Gulf of Kachchh and Gulf of Khambhat. In future the segregation process will start between Kachchh peninsula and Kathiawar-Saurashtra peninsula, the Gulf of Kachchh might go with the Gulf of Khambhat. If due to segregation the peninsula of Kuchchh and Kathiawar-Saurashtra are cut-off from the mainland of Gujarat, it could take the shape of separate islands. Thus, a second type of Taiwan will emerge in the Arabian sea. Now it is the area of severe active seismic zone of the world. When the earth rotates on its axis from west to east, a force is created within the interior of the earth. The resultant force tries to exert itself outwardly in the form of energy. As this force becomes more powerful, the weaker zones of the earth experience an earthquake. The recent earthquake of Bhuj is an example of this phenomenon.

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