SURFACE RISING MODEL OF CASPIAN SEA

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1

Figure 1:

Map of the **Caspian** Region

FORWARD

- The *environmental changes* in the **Caspian** Sea region cross over national boundaries and extend to many fields of research.
- This provides a broad opportunity for space technologies, specially *remote sensing* to link these fields for *better understanding*, *monitoring* and *well-managing* of the *region's environment* for *sustainable development*.
- As the largest lake on Earth sited in Asia, **Caspian** covers an area of 371,794 sq. km. It is so large that is called sea.
- Over the recent five million years **Caspian** has sometimes been a lake and other times a true sea linked to open waters through the Black and Mediterranean Seas and the Sea of Azov.
- It is agreed that **Caspian**'s shoreline has been shaped by global climate shifts that determine *sea levels* and rainfall.

THE PROBLEM THAT CONTINUES

- *Surface level change* of **Caspian** is one of its considerable *characteristics* since very ancient times.
- Its water level has *seesawed* dramatically for millennia.
- Increasingly warm weather and wider uses of irrigation have lowered the sea level.
- *Volga* is the greatest watershed of **Caspian**. In addition to Volga, Ural, and Terek rivers each with an extensively developed delta empty into northern **Caspian**.
- In south *Sefid Rud* and other Iranian rivers that empty to southern **Caspian** comprises 5 percent of all water entering the Sea.
- By 1993 the average water level of the sea had risen by more than 2 m. Since 1995 the sea level has been decreasing but there are evidences that the Sea's water surface has begun to rise since 1999.

MONITORING FROM SPACE

- The sea level change has had *physical*, *chemical*, *biological* as well as *economical* and *social impacts* on the **Caspian**'s littoral countries.
- For *estimating the damages* and *monitoring the process of sea surface rise* at **Caspian** there is a realization that remotely sensed data could be used.
- Although monitoring the damaged ecosystem of **Caspian** caused by sea surface fluctuations as well as the pollution and other human careless activities is much less expensive than the work of mending them, majority of the littoral states are mostly ill-equipped to monitor it.
- This project proposes setting up a *model* for *monitoring* and *forecasting* the *rises and downs* of **Caspian** to be incorporated to a *forecast* and *warning system*.

DATA

- The main input to the system is *frequent satellite data* of region.
- Water is highly reflective in the microwave range. Therefor using Medium Resolution Optical Image (MROI) as well as High Resolution Optical Image (HROI) data are applicable.
- Advanced Very High-Resolution Radiometer (AVHRR) sensor of NOAA provides MROI data, while the data of Landsat-TM, High Resolution Visible and InfraRed (HRVIR) of SPOT and Indian IRS-Pan data are HROI data useful to differentiate water bodies.
- HROI data collected by Landsat-TM gives a spatial resolution of nearly 30 m and temporal resolution of about 16 days.
- SPOT, on the other hand, with the resolution of 20 m in spectral and 10 m in panchromatic mode has a 26-day temporal resolution, while the IRS-Pan mode has the spatial resolution of 10 m and temporal resolution of 5 days.

- Consequently the *IRS-Pan* and *SPOT data* are *more suitable* in comparison to Landsat-TM data. MROI data acquired by NOAA-AVHRR has the spatial resolution of 1 km and temporal resolution of 12 hours.
- In microwave spectrum Synthetic Aperture Radar (SAR) images can be used. The two European ERS satellites with spatial resolution of 30 m and temporal resolution of 16 days and the Canadian RADARSAT with spatial resolution of 25-28 m in standard mode for four looks and the temporal resolution of 24 days are suitable.
- AVHRR as a typical MROI sensor, generally provides several high-latitude images every day suitable for observing the **Caspian** region. Although cloud cover is still a problem, increasing the frequency of coverage will increase the likelihood of obtaining the cloud-free images. With SAR data the sensors operate at wavelengths where signals travel almost unaffected through clouds.

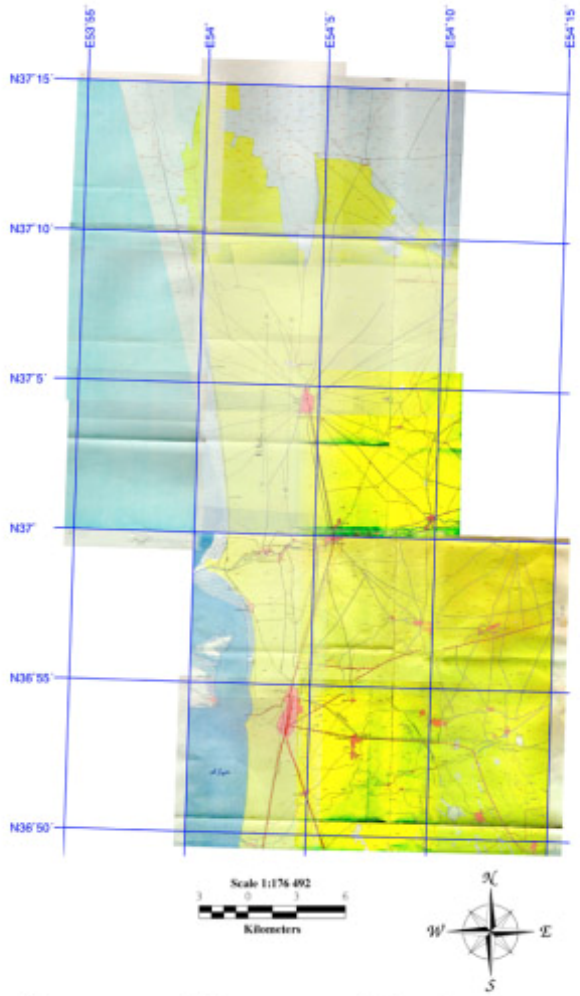
- The relatively *long repeat period* of HROI data ranging from 5 to 26 days, combined with the *high likelihood* of *cloud cover* in many places of interest needs to apply such kind of data carefully.
- The resolution of MROI sensors ranging from hundreds of meters to tens of kilometers limits the size of the area to be monitored.
- For HROI data the limits of the area under study ranges between 25 to 1000 sq. m, that is convenient for studying the water fluctuations.
- SAR, MROI and HROI in combination are the most reliable sensors for this mean, with SAR's cloud penetration capability, MROI's daily image acquisition and HROI's high resolution.
- The project uses *MROI* and *HROI* data in *visible* and *near infrared* range including NOAA-AVHRR, SPOT and IRS, and the European ERS or Canadian RADARSAT data in *microwave* range.
- *Geo-coding*, *information extraction*, *modeling*, *quality control* and *forecasts* all have to be completed within the scheduled period.

Figure 2:

Medium resolution image of **Caspian** Region collected by NOAA-AVHRR

MODEL

- The program consists of *two* phases.
- In the first phase a *mathematical model* of the rate of sinking the coastal lands due to sea surface rise will be set up.
- Using the obtained graphs the most *risky periods* during which the probability of sea rise is the highest will be determined accurately.
- The model uses a variety of *GIS* and *image analysis tools* including *ER-Mapper*, *Erdas Imagine* to combine the remote sensing data with other parameters such as *land-use*, *land-cover* and *topographic* data and will carry out subsequent modeling work.
- Comparison of the resulted information from the successive images will give the rate of sinking of the lands, and the most risky places exposed to damages of sea surface rise will be determined.
- In the second phase the places likely exposed to highest risk will be identified using land-use, land-cover and topographic data.



Topographic map of Study Area

Figure 3:

Topographic map of the south-eastern **Caspian**

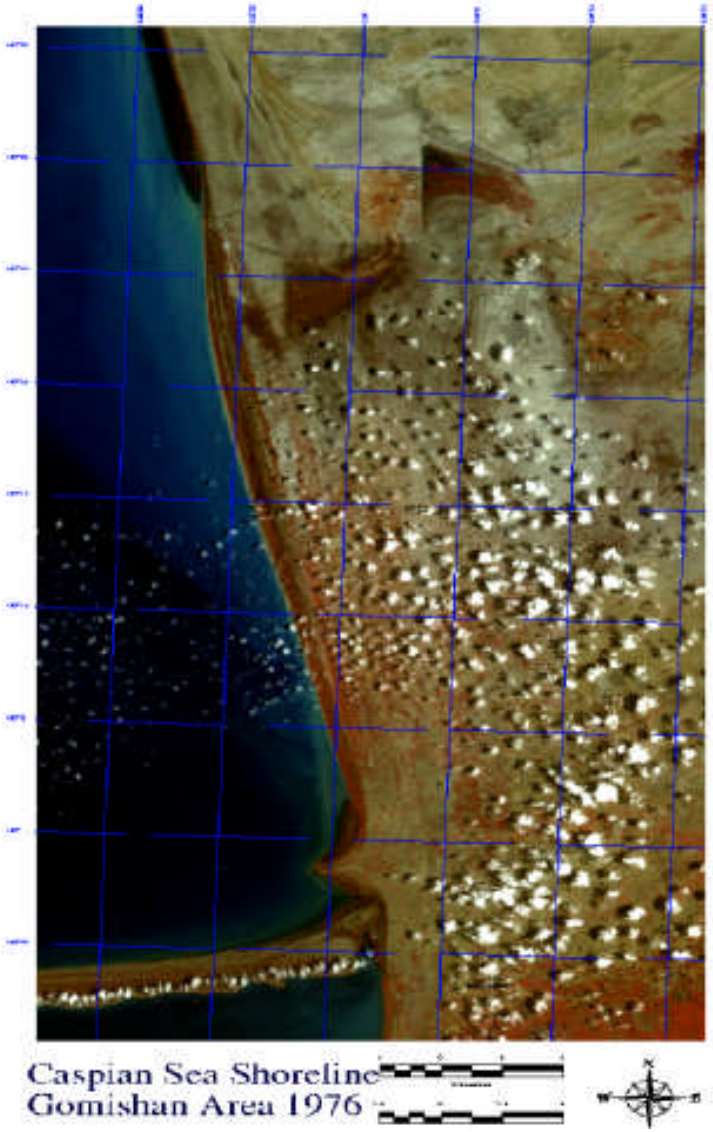


Figure 4-a:

MSS-1976 data of the south-eastern **Caspian**, the changes can be seen clearly comparing with the two other images.

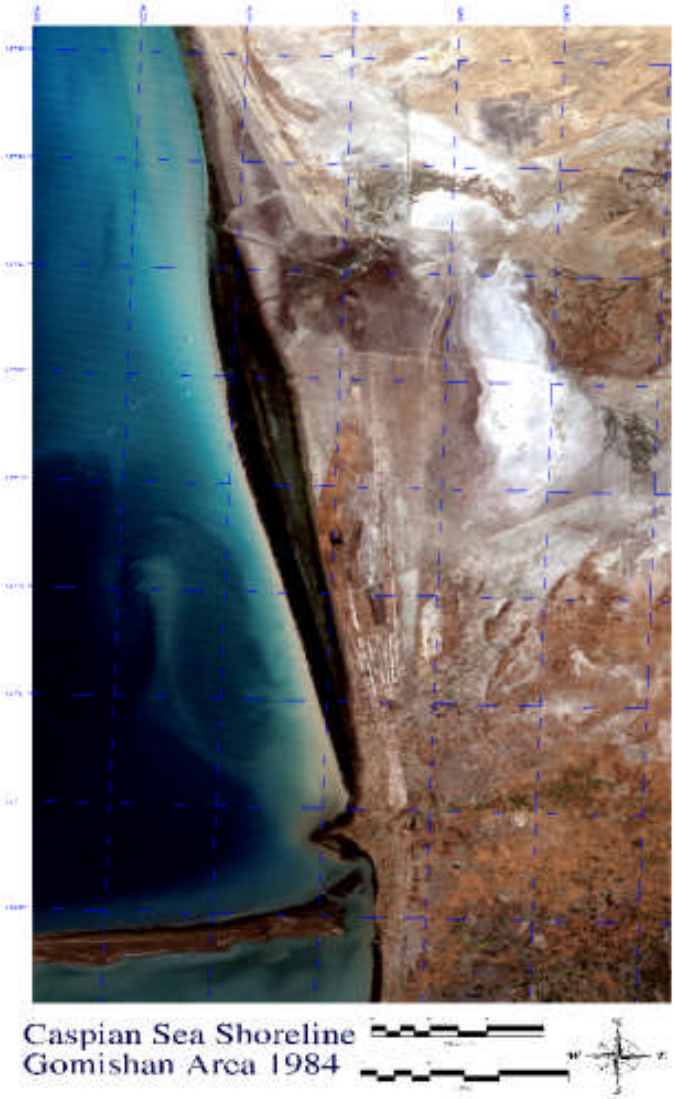


Figure 4-b:

TM-1984 data of the south-eastern **Caspian**, the changes can be seen clearly comparing with the two other images.

13

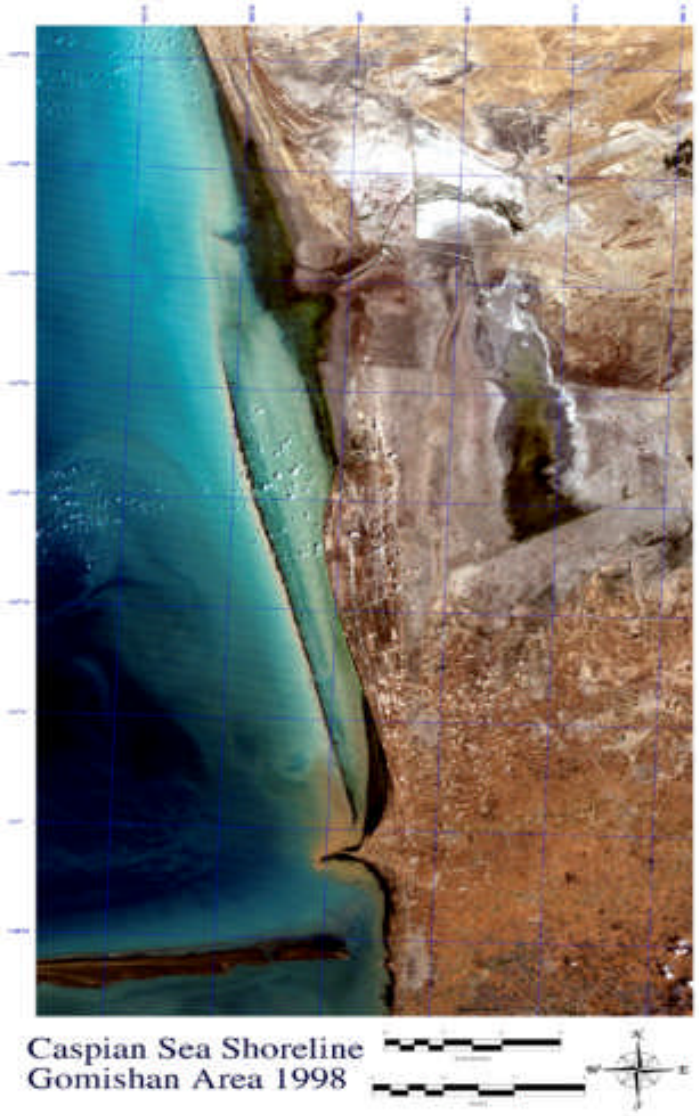


Figure 4-c:

TM-1998 data of the south-eastern **Caspian**, the changes can be seen clearly comparing with the two other images.

14

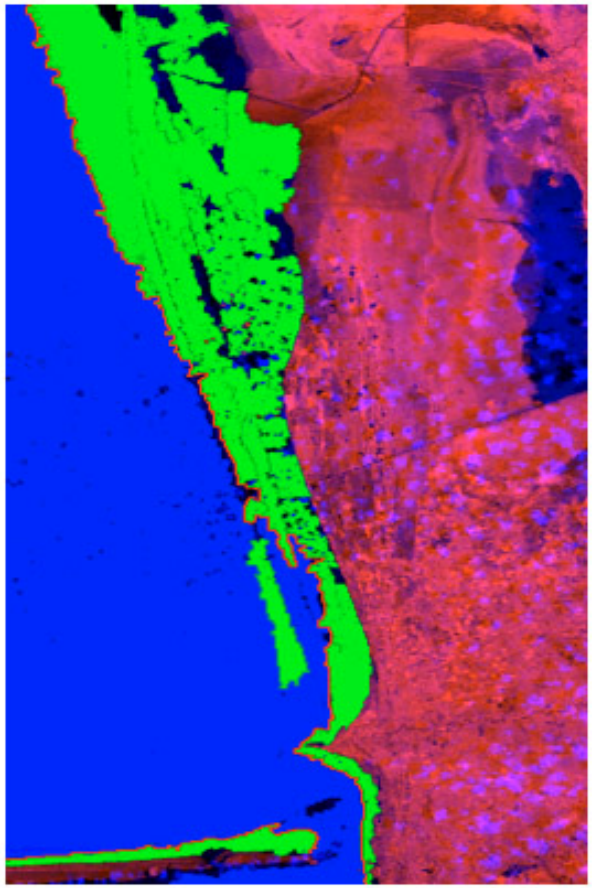


Figure 5:

Map of changes for the period of 1976 to 1998

EMERGING CONDITIONS AND POTENTIALS

- Investigations by the experts and specialists in the Iranian Remote Sensing Center show the results confirming the *proposed model*.
- Applying the data of the *south-eastern area* of **Caspian** situated in Iran for sea level fluctuations one can easily see the ups and downs of the sea level in different periods.
- The data includes *processed* and *geo-corrected* MSS-1976, TM-1984 and TM-1998 imagery.
- Comparing the images reveals the sea surface changes and map of the changes is produced for the period of 1976 to 1998.
- Although the methods and the results from the project are still need to be tested sufficiently, there is considerable *commercial interest*.
- Not only the study of sea surface rise at **Caspian**, but also the results acquired through this project can lead to a *joint co-operation* between **Caspian**'s *littoral states*.

- The outputs of this model can be used for *sustainable development* of region and its *environmental management* as well.
- Recommending the instructions based on the results of the project to the respective countries, they can take economic and convenient actions that may prevent the damages or diminish their effects.
- The results of the project will enable *decision-makers* and *planners* to propose the beneficial uses of the sea surface rise for *industrial*, *technical* and *environmental concerns*.
- The potential users of the results of project include the *organizations* in *governmental* as well as *private sector*.
- The organizations involved in urban, housing, fishing, forestry, agriculture, environment, tourism issues and many more are the potentially interested organizations in the results of the project.