Use of Space Technology for Natural Disaster Detection and Prevention

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Abstract:

Space technologies can play important roles in the reduction of disasters. The use of such technologies can be particularly useful in the risk assessment, mitigation and preparedness phases of disaster management. Space technologies are also vital to the early warning and management of the effects of the disaster. In order for the developing countries to be able to incorporate the routine use of space technology-based solutions there is a need to increase awareness, build national capacity and also develop solutions that are customized and appropriate to the needs of the developing world.

Keywords: space, technology, natural disasters, detection, prevention

During the past four decades, natural hazards such as dust storms, severe storms and tropical cyclones, droughts, floods, earthquakes, wildland fires, and volcanic eruptions, oil spills have caused major loss of human lives and livelihoods, the destruction of economic and social infrastructure, as well as environmental damages. Economic losses have increased almost ten times.

During this period. Losses from natural disasters will continue to increase if we do not shift towards proactive solutions. Disaster reduction is both an issue for consideration in sustainable development agenda and a cross cutting issue relating to social, economic, environmental and humanitarian sectors.

Early warning systems must be more than a technological instrument to detect, monitor and submit warning/alert. It should also include risk assessment and combine efforts by all sectors to plan ahead and build people’s capacity to respond rapidly at the local level and more specifically, to identify increasing vulnerabilities in their communities. It need to become part of a management information system for decision-making in the context of national institutional frameworks for disaster management as part of national and local strategies and programs for disaster risk reduction.

This paper shows the kinds of the natural disasters and examples of that disaster taken by different satellites in the Arab World, and how to prevent them.

1. AIR POLLUTION AND DUST STORMS:

Dust and smoke (Aerosols) are tiny particles suspended in the air. Some occur naturally, originating from volcanoes, dust, storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil prescribed fires, and alternation of natural surface cover, also generate aerosols. Many human-produced aerosols are small enough to be inhaled, so they present a serious health hazard around industrial centers or even hundreds of miles downwind. Additional, thick dust or smoke plumes severely limit visibility and can make it hazardous to travel by air or road. New research shows that aerosol pollution can modify cloud properties to reduce or prevent precipitation in the polluted
region-aerosols containing black carbon can impact climate and possibly reduce formation of clouds.

Wind erosion forms such as dunes or sand encroachment on infrastructure or cultivated fields may be recognized in aero space images if the scale and the sensor resolution permit, also sand dunes movement can be monitored moving multi temporal remotely sensed data.

C- Soil salinization:

Salinity problems can be seen directly on space image if the problem is severe, it will take along time before a uniform salt crust form on the soil surface, however the problem may be expressed in crop growth that can be detected, also several image processing techniques can be applied to extract information related to soil salinity.

D- Rangeland monitoring:

Satellite images have been used in rangeland monitoring. Much of this work has been done in the arid and semi arid land of the mid-western united states, also this was associated with the work on arid and semi arid lands developed for plague – locust monitoring by FAO and the biomass monitoring conducting by FAO and UNEP in the Sahelian region.

Satellite data are used to produce base maps of overall environmental types within the rangelands. This can be rapidly done and provides for a general understanding of the landform types-vegetation zooms, hydrology and geology of the area. We can use Landsat and NOAA satellites and their data.

The following is the recommended methodology to monitor desertification process using remote sensing techniques:

- Regional monitoring using low spatial resolution and high temporal resolution remotely sensed data, where the effected area can be highlighted.
- Identifying high special resolution remotely sensed data to monitor the affected areas.
- Digital processing of remotely sensed data such as geometric and radiometric correction enhancement classification and other related processing.
- Images preparation at suitable scales and format such as (FCC, NDVI).
- Visual images interpretation using different analytic factors, such as color, ton, pattern, location and stereoscopic vision if possible.
• Primary thematic maps preparation, which includes soil, vegetation cover, land use, land units and land degradation maps.
• Field check and field verification of the prepared maps as well as field data and samples collection.
• Correction of the thematic maps and preparation of the final maps and reports.

3. EARTHQUAKES:

The hazard can be covered by space-based systems in its various phases, mitigation, warning, and response. Earthquake mitigation can be achieved with a better knowledge of a region’s infra- and substructures. Basic topographic, geophysical, geological and structural map can help to understand a region’s vulnerability to seismic shocks. High resolution data can play a significant role in base mapping showing location of various infrastructures. Radar and laser altimetry are useful, especially over the ocean in order to map the geoids and gravity field. Laser ranging and very long baseline interferometric techniques were employed to measure fault motion. These techniques are now replaced by GPS. Near real-time application of space sensors, such as for damage mapping, when the relief agencies require imagery to locate possible victims and structures at risk is possible with resolution offered by IKONOS and Quick Bird systems.

- Earthquakes in the Middle East:

Several earthquakes occur along rift valley in Egypt, Syria, Jordan and Turkey.

4. FOREST FIRES:

Forest fires cause loss of human life and property, economic disruption, atmospheric disturbances. This hazard is divided into three phases: Preparedness, detection and response, and post-fire assessment.

Preparedness involves risk assessment, which in turn requires the knowledge of such variable as land use and land cover, forest fire history, demography, infrastructures, and urban interface. In this regard, remote sensing is used to derive vegetation stress variables, which are subsequently related to wildland fire occurrence.

The detection of forest fires is made possible by either sensing their thermal or mid-infrared signature during day and night, or detecting the light emitted by them at night.

In the post-fire assessment phase the most important consideration is the mapping of the burned areas and protection of watersheds as well as other critical
resources. As forest fires in Ras Al-Basit in Syria on October 28, 2004. fig. 5.

Fires in Turkey’s Adana Region and Northwest of Syria:

Dozens of fires were detected in the Adana region of Turkey on June 15, 2003, by (MODIS) on the Terra satellite. The have been marked with red dots in this true color image. The Adana region is a low lying coastal area ringed by the Taurus Mountains to the north and the Nur Mountains, covered in green vegetation, to the east. Because this region is one of the most agriculturally productive in the whole country, it is likely these fires are being used in for agricultural activities such as land clearing. At bottom right is Syria

Figure 5, Forest Fires in North-West of Syria.

Figure 6, A Terra Space Image of the Forest Fires in Syria and Turkey.

5. FLOODS AND Severe STORMS:

Remote sensing helps in monitoring the cyclones and mapping geomorphic elements and land use, providing meteorological data for hydrological modeling, and contributing to mapping historical events. On a local scale, land surface data on topography, hydrographic, and roughness of fluvial material are needed. Both electro-optical and microwave sensor can provide these data. Cartographic updates (DEMs) are a critical aspect of remote sensing. The flood preparedness warning means taking measure to protect human life and property. Plans for possible scenarios need to be prepared and appropriate resources to implement those plans need to be identified. Weather and watershed conditions (snow pack, etc) are some of more important factors in predicting and preparing for a flooding event.

Figure 7, Locations of Cyclones in the World.

1- Dam Break in Syria:

On Tuesday 4/6/ 2002 the Zeyzoun dam in northern Syria ruptured and collapsed, killing 20 people and leaving thousands more homeless. The satellite images taken on 5/6/2002 shows the extent of the flooding. Normally, there would be no water present in the center of the image on June 3, 2002. After the dam burst, 71 million cubic meters flowed onto the surrounding landscape and washed over an area of 9800 acres. Tenths of homes were destroyed in and around the village of Zeyzoun, Gastoun and Ziara, roughly 350 kilometers north of Damascus. Most of the residents fled to higher ground with the help of two helicopters. The Syrian originally constructed the dam to contain the Orontes River and provide a steady flow of water to the surrounding farms, many of which were lost. Rescue workers worry that more bodies may be found as the waters of the dam recede. The Syrian government is petitioning international aid agencies for further assistance.

The study That I carried out at GORS for flooded area by using TM space images, pointed out that the flooded area is 9800 acres of agricultural lands. The image below shows the flooded lands after the dam break>
6. LANDSLIDES:

Landslide mitigation involves primarily mapping of zones that at risk and their relevant terrain features. These maps can be produced at various scales using stereo aerial photographs, satellite images, and ground surveys.

Landslide warning and prediction to prepare for the disaster has been attempted by establishing the rainfall threshold where a landslide triggers. The Tropical Rainfall Measuring Mission (TRMM) is providing useful rainfall information for tropical areas.

Landslides-sudden, short-lived geomorphic events that involve the rapid-to-slow descent of soil or rock in sloping terrains - occur worldwide, often in conjunction with natural hazards like earthquakes, floods, or volcanic eruptions. Landslides can also be caused by excessive precipitation or human activities, such as deforestation or development, that disturb natural slope stability.

SAR images provide information on the terrain roughness and texture, while TM images provide an infrared reflection of the object.

7. OIL SPILLS:

Oil spill hazard is caused by tanker break-up at sea, or illegal discharge and tanker clean-up. The discharge is the more important of the two causes of oil spillage. Many countries have signed agreement such as MARPOL and UNCLOS and other regional protective agreements that forbid dumping of waste materials in the marine environment. Earth observation data are used operationally for enforcement and monitoring of oil spills by using radar and thermal data (Radarsat, ERS2, SPOT-5 and Landsat –TM) and other sensors data.

1- Oil Spill in the Arabian Gulf:

On February 16, 1991, large quantities of crude oil (5 millions barrel) penetrated into Dawhat Ad Dafi. This image shows the residual oil extracted from SPOT color data obtained on April 7, 1991.

8. VOLCANIC ERUPTIONS:

Volcanic eruptions are among nature’s most spectacular displays, at once both awesome and deadly. Volcanoes can present a major hazard to those who live near the for a variety of reasons (1) pyroclastic eruption can smother large areas of landscape with hot ash, dust, and smoke within a span of minutes to hours (2) red hot rocks spewed...
from the mouth of a volcano can ignite fires in nearly forests and town, while rivers of molten lava can consume almost anything in their path as they reshape the landscape: (3) large plumes of ash and gas ejected high into the atmosphere can influence climate, sometimes on a global scale. Fig. 11 shows locations of some active volcanoes in the world.

Figure 11, Locations of Some Active Volcanoes in the world.

9. ICE HAZARDS:

The remote sensing contribution to the ice hazard is mostly in the area of tracking and monitoring sea/lake ice. Real-time satellite data in the visible, infrared and microwave bands of spectrum are now used extensively. Space-borne SAR systems are the preferred data source in efforts to mitigate and assess the effects of this ice hazard.

Ice sheets are complex and dynamic elements of our climate system. Their evolution has strongly influenced sea level in the past and currently influences the global sea level rise that threaten our coast.

The break-up of the Larsen B ice shelf fig. 12 (3,300 km2) in Antarctica was observed by Envisat. The ASAR image acquired on March 18, 2002, shows that the collapsed ice has fractured into thousands of small icebergs and chunks, moving towards the Weddell Sea.

Figure 12, An Envisat Space Image of Ice Sheets in Antarctica.

10. OZONE DEPLETIONS:

The atmosphere is a blue haze that thins as it rises above the curve of the earth’s surface. Called the limb it provides a view of structure of the atmosphere. Orbiting scientific instruments look at the limb to measure how the concentrations of trace gases vary with altitude and monitoring of the Ozone hole. The Ozone hole can be detected by using NIMBUS-7, ERS-2 (GOME) and space shuttle (SOLSE-2).

11. SUN FLARES:

Every year, the Sun makes huge sun storms that affect on the Earth atmosphere, communications and satellites

12. NUCLEAR REACTOR EXPLOSIONS:

Some risks occur in the nuclear reactor, as in Chernobyl in Ukraine on April 29, 1986.

Adoption of the following specific recommendations would considerably enhance the utility of Earth observation space technology for disaster and environment risk management:

1. Preparing the new tectonic maps of the rift areas using remote sensing data, GIS and GPS in large scale.

2. Compile base-maps of high risk areas, and integrate with population distribution, infrastructure and building stock database, seismic history, relevant geology, know strain and Earth observation/topographic map merge for base-maps.

3. Continue investigation into areas of earthquake forecasting research (e.g. thermal, electromagnetic and space survey.

4. Support diversity of very high resolution missions to improve temporal resolution and coverage.

5. Bring very high resolution providers into International Charter to facilitate damage assessment.

6. Importance of the benefit of variety of spatial and temporal information from different sources in communications and GPS.

7. The information users are: National to local authorities, government agencies with
specific charge to mitigate against earthquake risk, national survey agencies, possible disaster management coordinating body, possibly some relief agencies (planning for disaster scenario), insurance/re-insurance industry, risk management consultancies, private enterprise (to mitigate financial impact and losses).

8- Using the media (radio, TV, newspapers and internet for capacity building and awareness increase.

9- Preparing the virtual flights over the risk areas by using space data.

10- Enhancement of the partnership between the related national, regional and international institutions.

11- Support the involvement of non-governmental organizations and local population in disaster reduction.

12- Establishing national organization for disaster management.

13- Establishing ground and space early warning network for natural disasters monitoring and prevent them.

14- Establishing very fast communications networks by satellites.

15- Organizing relief training courses in the risk areas.

16- Developing the international cooperation in using the space data in monitoring, studying and analyzing the natural disasters and its reduction.

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