Application of ALOS Data in Flood Monitoring in Pakistan

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Abstract:
Natural hazard such as flood is a water-related natural disaster which affects a wide range of environmental factors and activities related to agriculture, vegetation, human and wild life and local economies.
Recently Pakistan's southern provinces, Balochistan and Sindh were severely affected by flash floods, from 26 June to 10 July 2007. The floods were caused by torrential rains, gushing water from high altitudes of Kirthar to plains of Sindh significantly contributed in flooding. In this study the damage assessed by UNOSAT using data of Phased Array L-band Synthetic Aperture Radar (PALSAR) onboard Advanced Land Observing Satellite (ALOS) in combination with Tropical Rain Measurement Mission Satellite (TRMM) and other ancillary data greatly helped in finding the most affected areas. Also the unprocessed PALSAR images of pre and post flood periods downloaded from JAXA-ALOS site were used to assess change detection. As Pakistan is frequently affected by such disastrous situations, it is recommended that Digital Elevation Model (DEM) generated from Panchrometric Remote Sensing Instrument for Stereo Mapping (PRISM) onboard ALOS along with other optical data can be effectively used for flood mapping along River Indus for identification of most vulnerable areas.

Key words: Torrential rains, gushing water, flood, ALOS data, DEM

1. Introduction:

Flood is inundation of land by the overflow of unwanted water at the cost of lives of people and their livelihood.

Satellite data provide the capability to view the damage from multiple vantage points. The spatial resolution of an image determines the ability to view individual features such as buildings and bridges. It also helps to monitor and assess damage due to flood.

Riverine flood is more predictable and allows ample time to react whereas torrential floods leave almost no time to respond. Torrential floods have lesser frequency and duration but very high intensity and hence their impact is also severe. These floods normally occur in months of June, July and August when catchment areas in Balochistan receive heavy rains. Western boundary of Sindh is connected with Balochistan through Kirthar Hills. Pakistan's southern areas in Balochistan were badly affected by heavy rains in the months of June and July 2007. The cyclone roared the coastal areas of Balochistan on 14th of June 2007 causing the moisture in atmosphere which resulted in heavy rains in the southern areas of Pakistan which caused overflow of Turbat and Mirani Dams.

Balochistan's terrain including Kirthar Range, contains mostly hilly regions ranging upto 2000 meters height above mean sea level, which caused the flow of flash floods to the western Borders of Sindh.

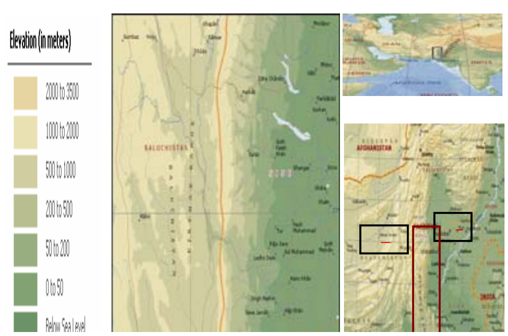

Figure 1. Encarta Map depicting terrain condition near the border of Sindh and Balochistan

A series of torrents brought gushing waters from high altitudes of Kirthar Range, Balochistan towards Sindh inundating vast areas of districts of Dadu and Shahdadkot / Qambar (Sindh)

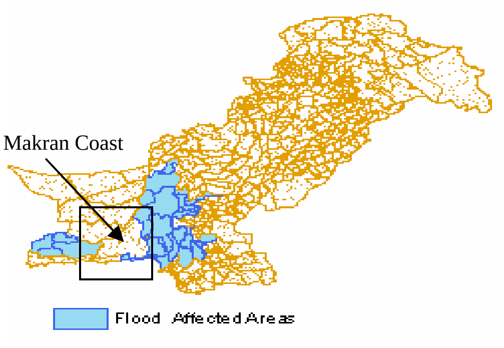

Figure 2. GIS based map showing inundated areas

Fig. 1 shows the terrain condition near the border of Sindh and Balochistan. The yellow line (dotted) is showing border line; locations in bright yellow colour show the elevation of 2000 to 1000 meters, fig. 2 shows GIS based map of Pakistan where the inundated areas are in blue colour, it can also be seem that Makran Coast was not inundated in spite of being attacked by heavy rains; this was due to elevation difference.

However for appropriate assessment of terrain condition, DEM could have been generated using PRISM data which is a panchromatic sensor and works in one band.

2. Case Study:

2.1. Study area:

The Study area includes flood affected villages of Balochistan and Sindh such as Gawadar, Sibi, Pasni, Jhal Magsi, Jaferabad, Nasirabad, Dasht, Kalakot, Kalat, Qamber, Shahdadkot, Mehar Taluka of Dadu district and Fareedabad Madu area.

2.2. Data Sets and Sources:

For the study of flash floods in Southern areas of Pakistan following Data Sets/Sources were used

(i) Under Collaboration with JAXA, Japan, images of Phased Array L-band Synthetic Aperture Radar (PALSAR) on board Advanced Land Observing Satellite (ALOS) images were used.

These PALSAR images helped to locate the flooded areas more correctly as it works in microwave region to achieve cloud free land observation and also gives spatial resolution of 10m and swath width of 70 Km.

(ii) PALSAR and MODIS images of affected areas provided by UNOSAT were used to detect flood affected areas.

(iii) Tropical Rain Measurement Mission Satellite (TRMM) data were used for rainfall measurement.

2.2.1. Methodology:

For a preliminary plan we needed to have DTM to have exact information about elevation differences. Yet analog or two dimensional terrains map has been used to assess reason of inundation at areas where no rain fall had occurred.

Immediate detection of flood inundated areas using satellite images of PALSAR and MODIS was done so that lives could be saved at appropriate time.

To determine the change in Indus River using PALSAR images of pre and post flood periods were used. These helped in understanding the flood situation at Indus Basin.

Graphs plotted between rain rate and flooded areas (i.e., location), were used to determine the extent of flood using TRMM data, we further used two dimensional terrain model of affected areas to determine the intensity and direction of flood.

Visual determination of direction of flash floods was done with the help of MODIS images so that an inevitable danger could be decreased.

2.3. Results and Discussion

A tropical cyclone, moving at a speed of 10 km per hour, packing winds ranging between 40 to 70 knots hit on 24 to 26 of June 2007 at the coastal areas of Pakistan that is Balochistan and

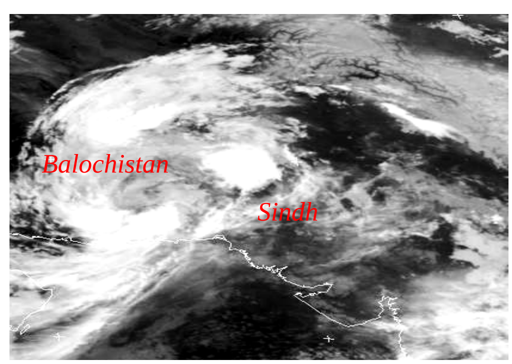

Figure 3. Meteosat Image of 26 June, 2007 showing tropical cyclone's formation

its villages. In fig. 3 Meteosat image is showing cloud coverage over Balochistan and Sindh on June 26 2007.
It caused heavy rains in Balochistan and Sindh. Fig. 4 depicts the graph between rain measurement and days for the months of June and July for different locations i.e. flood affected villages. It shows that Makran Coast in Balochistan experienced heavy rains.

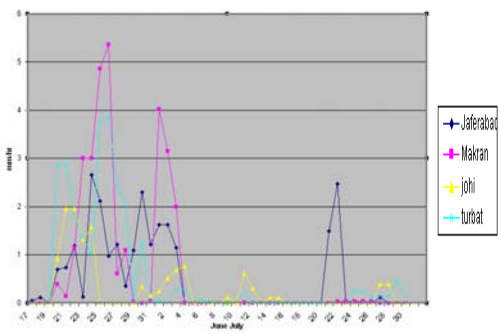

Figure 4. TRMM based graph of rain intensity Vs days for the month of June & July 2007 for some affected villages

The down stream areas of Turbat and Mirani Dam including Gawadar, Jaferabad, Nasirabad, Dasht, Kalakut, Kosh, Kalat and Tazag and several other villages were also badly affected by these ‘flashfloods’. In fig. 5 PALSAR and Radarsat composite image shows the flooded area of villages in Balochistan, depicted in blue color.
Flood water flowing from Balochistan via Qambar, Shahdadkot district and other villages near border due to abrupt elevation difference as already discussed above entered Mehar, Taluka of Dadu district on 06 July 2007 and inundated more 30 villages in Fareedabad, Madu area, as shown in fig. 6, which is a ALOS-PALSAR and

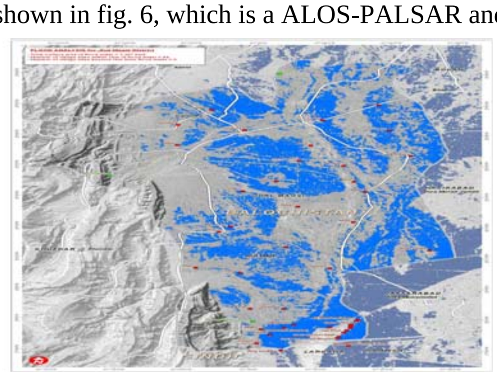

Figure 5. PALSAR-Radarsat image of 26 June 2007 and 05 July 2007 of affected areas of Balochistan, obtained from UNOSAT

Radarsat image of 26 June and 05 July 2007, obtained from UNOSAT. These flash floods resulted in inundation of more than 150 villages in three union councils near Shahdadkot district, Sindh.
To study the variation in the pattern of Indus basin we used ALOS-PALSAR images obtained with the collaboration of JAXA, Japan. As shown in figure 7, 8 and 9, these satellite images

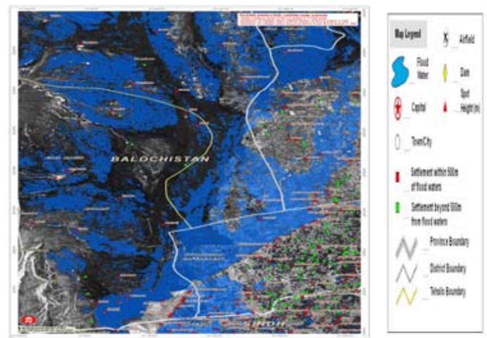

Figure 6. PALSAR mage obtained from UNOSAT showing unwanted flood water over the land (Dadu-Sindh) in blue colour.

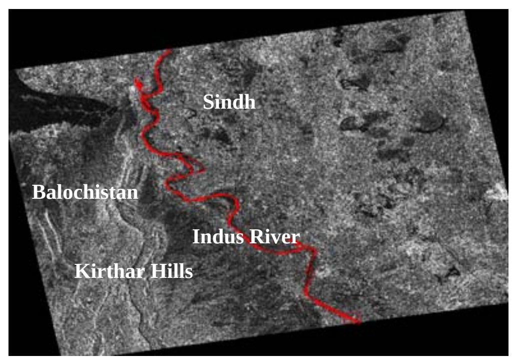

Figure 7. PALSAR image of February 08, 2007 indicating pattern of Indus Basin, obtained from JAXA

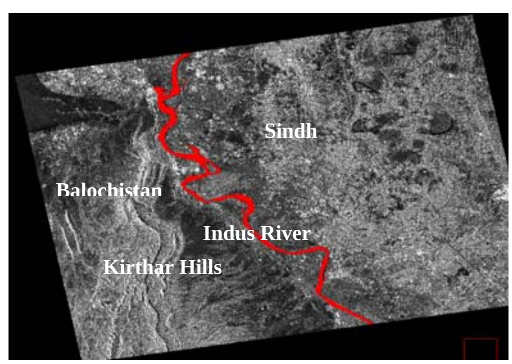

Figure 8. PALSAR image of June 26, 2007 indicating pattern of Indus Basin, obtained from JAXA

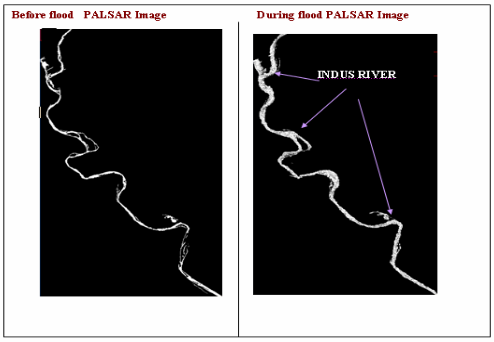

Figure 9. Envi Software-Subset via roi technique applied on PALSAR images of pre and post flood situation indicating the change in pattern of Indus Basin, obtained from JAXA

helped to study the cloud free conditions of affected land so that affected areas could be correctly located. The images shown below give a simple vision of flooding in Indus Basin during flood.

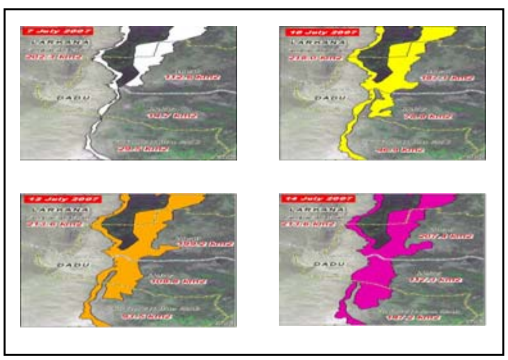

Figure 10. MODIS images of Dadu district, showing direction of flash floods Sindh

In fig. 10 the images illustrate satellite detected flood water changes during a seven day period (7-14 July 2007) in Dadu district. Flood estimates were made using MODIS images recorded during this period.

3. CONCLUSION:

With tools provided by space technology, man toady is far better prepared and equipped than his ancestors ever were to cope with disasters like flood and to mitigate or minimize the losses to life and property in such situation to an appreciable extent. Today, flooding situation can be better monitored and assessed and timely precautionary steps can be taken during the pre-flooding stage as well as while the flooding lasts, to avoid or minimize loss of life and property and implement efficient relief operations in the post-flooding phase.

TRMM and ALOS data along with other ancillary data greatly helped in monitoring floody situation in Balochistan and Sindh June-July 2007. This kind of disaster which occurred specially in Sindh & Balochistan was unpredictable according to its historical climatic conditions.

The year 2007 was not only year of disasters for Pakistan, but such types of disaster have occurred all over the world, like 770 people died in China, 50 people died in Sudan and there were many more examples.

To further enhance flood monitoring / mitigation capabilities, the following will be considered:

- Results of the findings will be integrated with related parameters DEM and DTM
- Findings will be used to develop intervention/mitigation measures at different levels
- International collaboration on space technology and applications should promoted

4. Acknowledgement

Efforts and assistance rendered to Pakistan by international community including JAXA, Earth Observation Resource Centre, Japan and UNOSAT for providing valuable satellite data pertaining to various disasters especially earthquake of October 2005, and June - July 2007 Balochistan and Sindh flood, is highly commendable.

The authors also wish to extend appreciation and thanks to Mr. Kazuo Ohta of JAXA, Japan. Dr Zhong Liu, George Mason University, NASA Goddard Earth Sciences & Data and Information Center NASA / GSFC, for providing TRMM data pertaining to June-July 2007 rain in Sindh and Balochistan.

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