UTILIZATION OF SPACE BASED INFORMATION FOR DISASTER MONITORING IN PAKISTAN

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SUPARCO, PAKISTAN

October 25, 2013
1. Introduction

2. Disaster Monitoring & Mapping
   - Earthquake 2013
   - Floods 2013
   - Monsoon Contingency Planning

3. International Collaborative Work

4. Space education & Awareness

5. Conclusion

6. Recommendation
Introduction
PAKISTAN - Key Statistics

Economic Survey 2011-2012

- Population: 180 million
- Area: 796,000 sq km
- Agric Area: 230,000 sq Km
- Agriculture: 24 % of GDP
Pakistan Space & Upper Atmosphere Research Commission (SUPARCO)

- Pursue R&D activities in space science, space technology and allied fields for achieving the objective of self-reliance
- Advise the government in all space related matters
- Liaise with national & international agencies
Atmosphere Data Processing & Receiving Centre (ADPRC) 
Karachi 

Satellite Ground Station (SGS) Islamabad
Satellite Aided Search and Rescue Program (COSPAS-SARSAT)

- Constellation of Russian, US, French and Canadian Geo-stationary & LEO Satellites
- Receives Distress Signals from Aircrafts, Vessels, Personnel
- 121.5 MHz, 243 MHz and 406 MHz Beacons
1st October 2010 ELT Alert of UN Helicopter Crashed Near Dadu Sindh

UN Helicopter (26° 32’ N 067° 36’ E)

Date: 1st October 2010

Location: Dadu, Sindh

No. of persons rescued: 12
Disaster Monitoring and Mitigation
Natural Disasters

The Rising Costs for Mankind

Graph by Robert Simmon, based on data (Upto 2005) courtesy EM-DAT. The OFDA/CRED International Disaster Database (www.em-dat.net) Université Catholique de Louvain—Brussels, Belgium

Average Cost is beyond 50 Billion USD

Advanced Technologies like Remote Sensing could help in lowering these costs
Natural Disasters
Events in Pakistan

- Earthquake 2005
- Hunza Landslide - 2010
- Avalanche 2012
- Earthquake 2013
Natural Disasters

Earthquake/Landslides (2005)

- October 8, 2005 at 08:52:37 PST
- 34° 29′35″N 73° 37′44″E
- 79,000 dead, 106,000 injured
- 17th deadliest earthquake of all time
Extensive riverine inundation and flash flooding in the mountainous regions.
Prolonged rainfall inundations in the lower Indus river region.
Hill torrents and flash floods in the western sub-catchments of Indus.
At all tiers of a National Disaster Management Framework, the availability of reliable data on spatial reference is of paramount importance for right decision making.
SUPARCO Role in Disaster Management

SUPARCO’s assistance includes:

- Rapid Regional coverage of disaster events
- Extent of disaster + imminent damages
- Estimation of losses to crops and infrastructure
- Suggest floods water flow directions/mapping
- Monitoring of breaches in embankments/bunds
- Monitoring recession of water
- Monitoring rehabilitation process
- Flythrough/3D model etc to ascertain level of damage
- Emergency Communication service through PAKSAT-1R
- Climate change impact assessment-Monitoring depletion of glaciers/snow melt
Work in Two Phases

Work Process At SUPARCO

Rapid Mapping

Quick Response to Disaster
Automatic map generation through Custom Developed Software
MODIS, SPOT 4, SPOT 5, Vector data

Detailed Assessment

Ground surveys
Damage Analysis for Infrastructure, Agriculture, Household etc.
Detailed Reports
Earthquake 2013
PAKISTAN EARTHQUAKE, SEPTEMBER 24, 2013

This is a rapid map based on pre-earthquake MODIS imagery of Sept 23, 2013. There are several active fault lines near the epicenter located in District Awaran (Balochistan). Magnitude of the earthquake was 7.7 while the depth was 10 Km. This map is created on September 24, 2013 at SUPARCO.

SUPARCO is host to the UN-SPIDER Regional Support Office (RSO) in Pakistan

Data Sources: PMD, GSP
Projection & Datum: WGS 84

Legend
- Epicentre
- Major City
- Active Fault Line
- International Boundary
- District Boundary

Distance from Epicenter (in km)
- 0-75
- 76-150
- 151-225
- 226-300
- 301-375
- 376-450
PAKISTAN EARTHQUAKE, SEPTEMBER 24, 2013
LABACH CITY, BALOCHISTAN - AFFECTED INFRASTRUCTURE

Legend

Damaged Structures

Total building structures: 1500 (approx.)
Damaged building structures: 80 (approx.)

This map presents the preliminary analysis of the earthquake-affected area of Labach City, District Awaran (Balochistan). This analysis is based on 0.5 m resolution imagery collected by PLEIADES satellite on September 26, 2013. This analysis has yet to be validated in the field.

This map has been produced at SUPARCO on September 26, 2013.

Projection & Datum: WGS 84
Floods 2013
This map shows the extent of River Chenab on August 20, 2013 as compared to June 23, 2013.

This analysis is based on pre & post disaster satellite imagery collected by SPOT sensors at Satellite Ground Station SUPARCO Islamabad. This analysis has yet to be validated in the field.

Projection: UTM Zone 42 N
Datum: WGS84

SUPARCO is host to UN-SPIDER Regional Support Office in Pakistan.
This map shows the pre and post monsoon behaviour of River Indus between Guddu and Sukkur Barrages. The settlements in the Indus plain which are highly prone to flooding are indicated. Widening past the normal course of River Indus could be seen. Important bunds are highlighted with red arrows. This analysis is based on Landsat 8 data of 20th and 27th August, 2013. The map is produced on August 28, 2013.

Projection: UTM Zone 42 N
Datum: WGS 84
Contingency planning
Estimation of Snow Cover During 2008-2013 (Entire Indus Basin)
(http://www.suparco.gov.pk/pages/pak-scms.asp)
River Flow

Indus River Monthly Average Flows (m³/sec) above Terbela Dam

Forecast for Year 2013
Expected River Runoff

River Flow

Forecast for Year 2013
Expected River Runoff

Indus River Monthly Average Flows (m³/sec) above Terbela Dam

April
May
June
July

2008
2009
2010
2011
2012
2013

m³/sec

2000
3000
4000
5000
6000
7000
8000
9000

0
1000
2000
3000
4000
5000
6000
7000
8000
9000

2008
2009
2010
2011
2012
2013

River Flow
Conclusion of Study

- Snow Cover in 2013 is higher as compared to rest of the years and it is expected that snowmelt will be higher as compared to previous years (2008-2012).
- Results show increasing trend in snow cover from 2008 to 2013.
- Higher temperatures will result higher flows in rivers as compared to previous years.

Improvements to the Climate change monitoring concept can be achieved through:

- Inventorying glacial databases
- Temporal monitoring snow/glacial melt using Earth Observation satellites
<table>
<thead>
<tr>
<th>District</th>
<th>Max Inundated Area (Sq Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badin</td>
<td>3751</td>
</tr>
<tr>
<td>Bahawalnagar</td>
<td>81</td>
</tr>
<tr>
<td>Benazirabad</td>
<td>850</td>
</tr>
<tr>
<td>Dadu</td>
<td>360</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>151</td>
</tr>
<tr>
<td>Jacobabad</td>
<td>517</td>
</tr>
<tr>
<td>Jaffarabad</td>
<td>211</td>
</tr>
<tr>
<td>Jamshoro</td>
<td>154</td>
</tr>
<tr>
<td>Jhel Magsi</td>
<td>146</td>
</tr>
<tr>
<td>Kasur</td>
<td>138</td>
</tr>
<tr>
<td>Khairpur</td>
<td>268</td>
</tr>
<tr>
<td>Matliari</td>
<td>325</td>
</tr>
<tr>
<td>Mirpurkhas</td>
<td>1694</td>
</tr>
<tr>
<td>Nasirabad</td>
<td>75</td>
</tr>
<tr>
<td>Naushero Ferze</td>
<td>376</td>
</tr>
<tr>
<td>Sanghar</td>
<td>2554</td>
</tr>
<tr>
<td>Tando Allahyar</td>
<td>462</td>
</tr>
<tr>
<td>Tharparkar</td>
<td>197</td>
</tr>
<tr>
<td>Thatta</td>
<td>622</td>
</tr>
<tr>
<td>TM Khan</td>
<td>346</td>
</tr>
<tr>
<td>Umerkot</td>
<td>754</td>
</tr>
<tr>
<td>Vehari</td>
<td>50</td>
</tr>
</tbody>
</table>

**Total** 140961

*Data Provided by SUPARCO through Satellite Imagery*

- 20th February 2012
- Max Inundated Area (Sq km)

**Timeline of Inundated area in sq.km**


**93% Receded**

Prepared by Information Management Unit - FAO-ERCU - Pakistan @ 2011
Damage to Agriculture

![Graph showing area affected by flood extent and damaged cropped area for different regions.]

Area in 000 ha

- Badin
- Bahawalnagar
- Benazirabad
- Dadu
- Hyderabad
- Jacobabad
- Jafarabad
- Jamshoro
- Jhal Magsi
- Kasur
- Khairpur
- Matiari
- Mirpurkhas
- Nasirabad
- Naushahro Feroz
- Sanghar
- Tando Allahyar
- Tharparkar
- Thatta
- TM Khan
- Umerkot
- Vehari

Flood Extent (000 ha) and Damaged Cropped Area (000 ha)
Damage Assessment Reports
Storage of Torrential Rain water ( case study )
The satellite remote sensing and GIS technologies are very useful for the pre feasibility studies to select dam sites. A detailed study is recommended which may include the following parameters:

- Geological structural capability
- Behavior of regional mountain
- Affect of sedimentation
Tele-epidemiology

DENGUE FEVER
District Lahore: Spatial distribution of Dengue Case for 2009

<table>
<thead>
<tr>
<th>Town</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wahga Town</td>
<td>23</td>
</tr>
<tr>
<td>Data Gunj Baksh Town</td>
<td>16</td>
</tr>
<tr>
<td>Samanabad</td>
<td>13</td>
</tr>
<tr>
<td>Allama Iqbal Town</td>
<td>7</td>
</tr>
<tr>
<td>Gulberg Town</td>
<td>6</td>
</tr>
<tr>
<td>Nishtar Town</td>
<td>6</td>
</tr>
<tr>
<td>Aziz Bhatti Town</td>
<td>3</td>
</tr>
<tr>
<td>Ravi Town</td>
<td>3</td>
</tr>
<tr>
<td>Shalimar Town</td>
<td>3</td>
</tr>
<tr>
<td>Cantonment Town</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>81</strong></td>
</tr>
</tbody>
</table>

This analysis was performed on the basis of dengue fever data provided by Health Department Govt. of Punjab, Lahore.

Projection: UTM Zone 42 N
Spheroid: WGS 84
Factors analyzed for Correlations with Dengue Cases

- NDVI
- Population Density
- Landuse/Landcover
- Land surface Temp

**Average Humidity (2007-2011)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>44.0</td>
</tr>
<tr>
<td>2008</td>
<td>43.3</td>
</tr>
<tr>
<td>2009</td>
<td>41.5</td>
</tr>
<tr>
<td>2010</td>
<td>46.4</td>
</tr>
<tr>
<td>2011</td>
<td>47.2</td>
</tr>
</tbody>
</table>

Relative Humidity
INTERNATIONAL COLLABORATIVE WORK
• SUPARCO is Regional Support Office of UN-SPIDER- It has participated in two TAM Missions (Bangla Desh & Sri Lanka)
• Being National Space Agency, it represents Pakistan at APSCO forum
• SUPARCO is a member of Regional Space Application Programme (RESAP) being undertaken by UNESCAP
• SUPARCO is also member of JPT-2, Sentinel Asia
Strategic Strengthening of Flood Warning and Management Capacity of Pakistan

✓ Project Associates
  o SUPARCO/PMD/UNESCO/JAXA

✓ Objectives
  o Development of Indus-Integrated Flood Analysis System (IFAS)
  o Update flood hazard maps by using satellite data including newly flood affected areas
  o Test operation in Feb 2014

Geographic area to be covered by Indus-IFAS (enclosed by dotted lines)
Proposed Flood Hazard Mapping Area (Lower Indus)
Several GIS layers have been prepared in a buffer of 20km across the Indus River from Chashma down to delta where it merges with sea.

**GIS Layers:**
- Settlements
- Roads
- Embankments
- Railway line
- Bridges
- Agriculture land
Draft Web Portal

- **Pre-Disaster (Preparedness)**
  - Interactive GIS tool
  - Risk mapping at district level
  - Vulnerability assessment
  - Evacuation plans
  - Safest route identification
- **Post Disaster (Response)**
  - Damage assessment
  - Damage Need Analysis
  - Information dissemination
As part of the FAO Pakistan Floods Relief and Early Recovery Response Plan, The GeoData Institute, UoS is coordinating a River Bank Erosion Modelling and Impacts on Agriculture Project on the Indus River from Chashma to Taunsa to provide early warning of hot spots of erosion, embankment breach and agricultural losses. It would also provide input to flood hazard maps.
4 Key Activities

- Mapping of erosion based land loss and agricultural impact on the river Indus due to 2010 floods

- Statistical analysis of 20 years of satellite data for trend analysis of historical hot spots of erosion

- Conduct field tests of characteristic geotechnical properties of riverbanks to model likely impacts of given flood events on agricultural land and production as well as high potential for embankment breech

- Build capacity in country to conduct analysis and field work with joint production of erosion models based upon flood work and associated reporting/publications
Land Cover Mapping

Land Cover Mapping is an ongoing project in collaboration with FAO UN using the technique of Land Cover Classification System (LCCS) – an important component of FAO / GLCN approach to create a harmonized and extensive representation of land cover features.

The possible areas of application would be Agriculture, Forestry, Environment, Irrigation, Disasters & Hazards Monitoring, Planning & Development, Oil & Gas Exploration, Mining, Wild Life and other emergent requirements.
<table>
<thead>
<tr>
<th>Agg. Code</th>
<th>Original land cover class</th>
<th>Agg. Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tree Orchards - TCOr</td>
<td>Orchards</td>
</tr>
<tr>
<td>1</td>
<td>Shrub Orchards - SCOr</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Herbaceous Crop Irrigated - HCrI</td>
<td>Crop irrigated</td>
</tr>
<tr>
<td>2</td>
<td>Herbaceous Crops surrounded by Tree Orchards - HTCOr</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Herbaceous Crop Rainfed in Desert area - HCrFD</td>
<td>Crop Marginal and Irrigated Saline</td>
</tr>
<tr>
<td>3</td>
<td>Herbaceous Crop Irrigated - Saline Fields - HCrIS</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Herbaceous Crop Irrigated in Flood Plain – HCrIFP</td>
<td>Crop in flood plain</td>
</tr>
<tr>
<td>4</td>
<td>Herbaceous Crop post-flooding – HCrpf</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Herbaceous Crop Rainfed - HCrF</td>
<td>Crop Rainfed</td>
</tr>
<tr>
<td>5</td>
<td>Herbaceous Crop in Sloping Land - HCSL</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Trees Forest Plantation – TFP</td>
<td>Forest - (Natural trees &amp; Mangroves)</td>
</tr>
<tr>
<td>6</td>
<td>Trees Closed - TNC</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Trees Open - TNO</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mangroves - MN</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Shrub Closed (with Trees Sparse) – SNC</td>
<td>Range Lands - Natural shrubs and herbs</td>
</tr>
<tr>
<td>7</td>
<td>Shrub Open (with Trees Sparse) - SNO</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Herbaceous Closed to Open (with Trees and/or Shrubs Sparse) – HNCo</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Built-Up Area – BU</td>
<td>Built up</td>
</tr>
<tr>
<td>9</td>
<td>Sand Dunes (Desert) – SaD</td>
<td>Bare areas</td>
</tr>
<tr>
<td>9</td>
<td>Barren Land (with Sparse Vegetation) - BL</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Sand Dunes with Natural Vegetation - SaDNV</td>
<td>Bare areas with sparse natural vegetation</td>
</tr>
<tr>
<td>10</td>
<td>Bare Rocks (with Sparse Vegetation) - BRSV</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Desert Flat Plain - SaFP</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Mud Flat - SaW</td>
<td>Wet areas</td>
</tr>
<tr>
<td>11</td>
<td>River Perennial - Rp</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Salt Lake - SL</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Water Bodies - WB</td>
<td></td>
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<tr>
<td>11</td>
<td>Saline Area (with Shrubs Sparse) – SA</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Water Logged Bare Area - WLBA</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Snow Permanent - SnP</td>
<td>Snow and Glaciers</td>
</tr>
<tr>
<td>12</td>
<td>Glacier - GI</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>River Bank - RB</td>
<td>Natural vegetation in wet areas</td>
</tr>
<tr>
<td>13</td>
<td>Shrub Closed to Open in Wetland - SNcoW</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Trees Open in Wetland- TNoW</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Trees Closed in wetland- TNCw</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Wetlands (with Natural Vegetation) - GFWN</td>
<td></td>
</tr>
</tbody>
</table>
Result Announcement of the selection for candidate proposals of the Application Pilot Projects for APSCO Data Sharing Service Platform Project

By Department of Strategic Planning and Program Management of APSCO

18 September 2012, Headquarters of APSCO

On APSCO’s invitation of its Member States for proposals on the Application Pilot Projects for APSCO Data Sharing Service Platform Project, 11 proposals were received from Bangladesh, China, Peru, and Thailand. After evaluation by APSCO invited experts as the evaluation committee, the prioritize recommended list of proposals are shown as below:

<table>
<thead>
<tr>
<th>Project</th>
<th>Rank</th>
<th>Country</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation of Different Remote Sensing Techniques for Drought Study</td>
<td>1</td>
<td>Pakistan</td>
<td>Selected</td>
</tr>
<tr>
<td>Urban Land Use Change Detection and Modeling Using Remote Sensing and GIS in Pakistan</td>
<td>2</td>
<td>Pakistan</td>
<td></td>
</tr>
<tr>
<td>Strengthening of Satellite Based Crop Monitoring and Estimation System for Food Security Application in Bangladesh: Application of APSCO Data Sharing</td>
<td>3</td>
<td>Bangladesh</td>
<td>Selected</td>
</tr>
<tr>
<td>Training Program on the Nature Disaster Monitoring and Assessment with Remote Sensing Technology</td>
<td>4</td>
<td>China</td>
<td></td>
</tr>
<tr>
<td>Remote Sensing Monitoring of Ecological Impact Resulting from Mineral Resource Developing and its Applicative Demonstration</td>
<td>5</td>
<td>China</td>
<td></td>
</tr>
<tr>
<td>Estimation of Rice Field using Multiple Satellite Sensors</td>
<td>6</td>
<td>Thailand</td>
<td>Selected</td>
</tr>
<tr>
<td>Climate Change Impacts on Glacial Lakes and Related Hazards</td>
<td>7</td>
<td>Pakistan</td>
<td></td>
</tr>
</tbody>
</table>
**TRAINING COURSES IN RS & GIS**

- **MS (RS & GISc) program** at NCRG, Karachi commenced on 07 Dec 2009
- 2 ½ years spread over 5 semesters (Two semesters per year)
- 30 credit hours including thesis

- **Short Term Training Courses** at NCRG for National and international user organizations on regular basis
Conclusion

It is imperative to utilize space based technologies into Disaster Management
Institutional linkages need to be strengthened for utilization of space resources and expertise among developing & developed countries.