



**unitar**

United Nations Institute for Training and Research

# Multiscale & Multitemporal Satellite Flood Monitoring



**Wendi Pedersen**

**UNOSAT**

*Use of Space Applications in Humanitarian Operations; Warsaw, Poland (May 2012)*

## What is UNITAR?

- United Nations Institute for Training and Research
- Innovative training and applied research on knowledge systems for increased efficiency of the UN and its Member States
- Mandate from 1965 focusing on: **Environment; Peace, Security, Diplomacy and Governance**
- Offices: Geneva (HQ), New York, Hiroshima, Brasilia

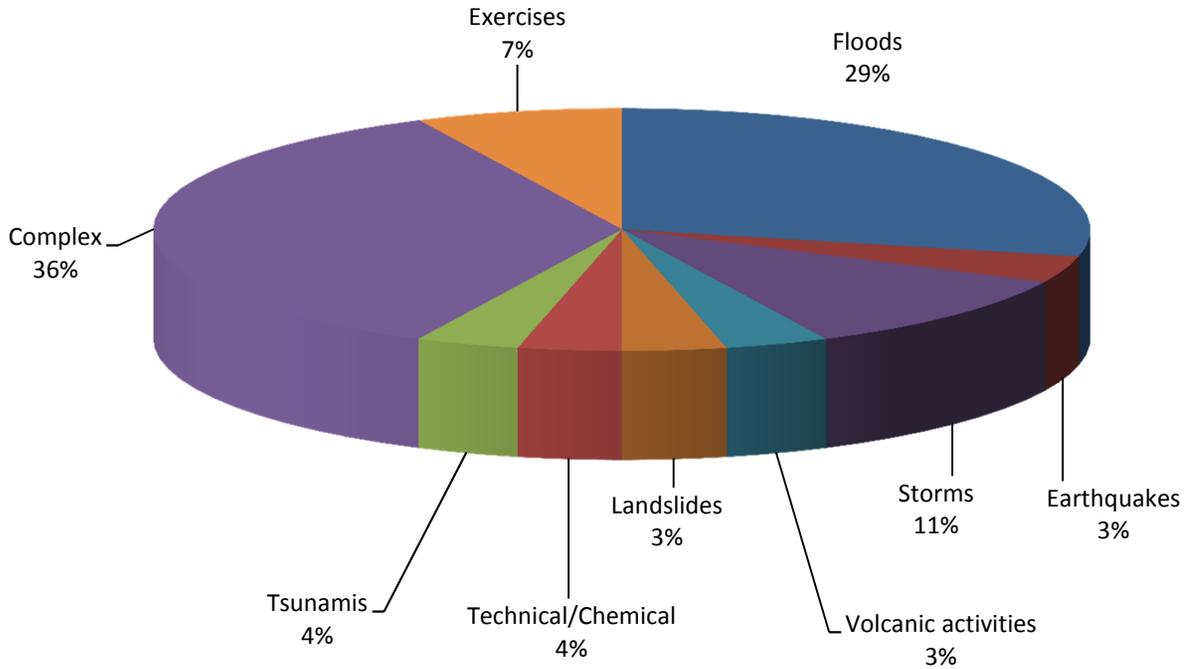
knowledge, international, participatory approach, r  
diversity, innovation, knowledge sharing, research  
hip, transfer, expertise, new technologi  
learning by doing, network  
ship, skills building  
ing, ext

## What is UNOSAT ?

- UNOSAT: Operational Satellite Applications Programme of the United Nations Institute for Training and Research (UNITAR)
- 11 years of DOING! Operational support from the ground-up
- Covering all types of disasters, small and big, on average 35 events per year
- With partner network a centre of excellence in applications of satellite imagery

# UNOSAT rapid mapping by type of emergency

## 2011



knowledge, international, participatory approach, r  
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## Hunza Landslide: January 4<sup>th</sup> 2010

A massive landslide blocked the Hunza river near Attabad in Gilgit-Baltistan creating a natural dam that retained river water during the glacial melt season.

- Blocked flow of the Hunza River for 5 months.
- 16.37km of Karakoram Highway (KKH) Flooded
- As of 31<sup>st</sup> May lake size ~ 875 ha





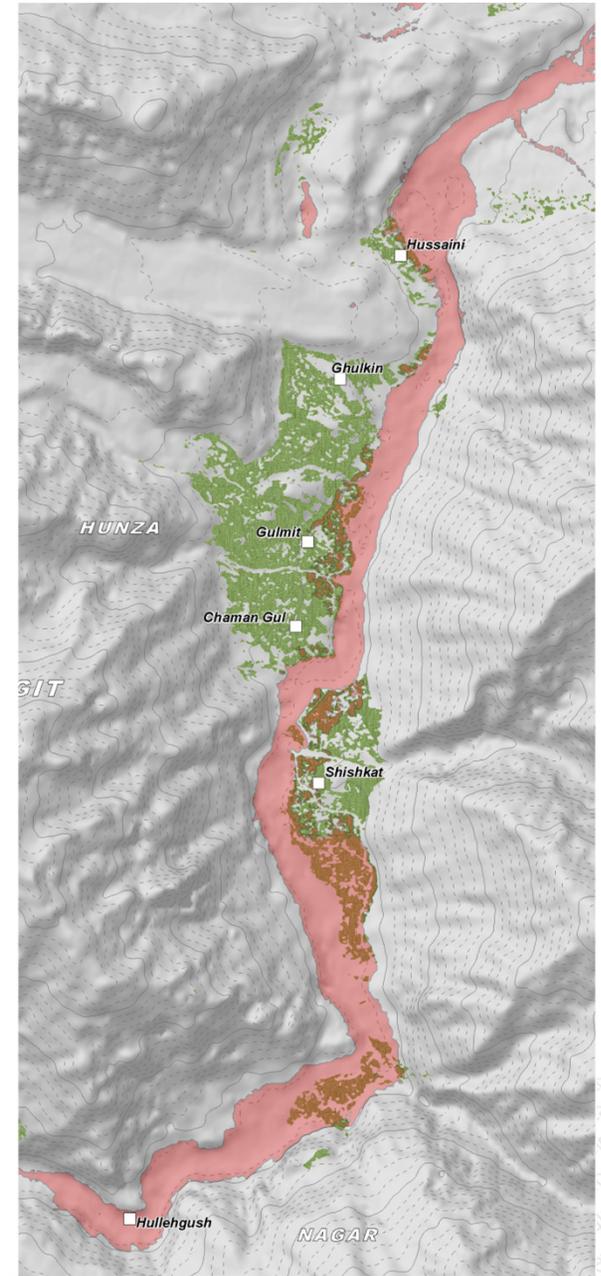
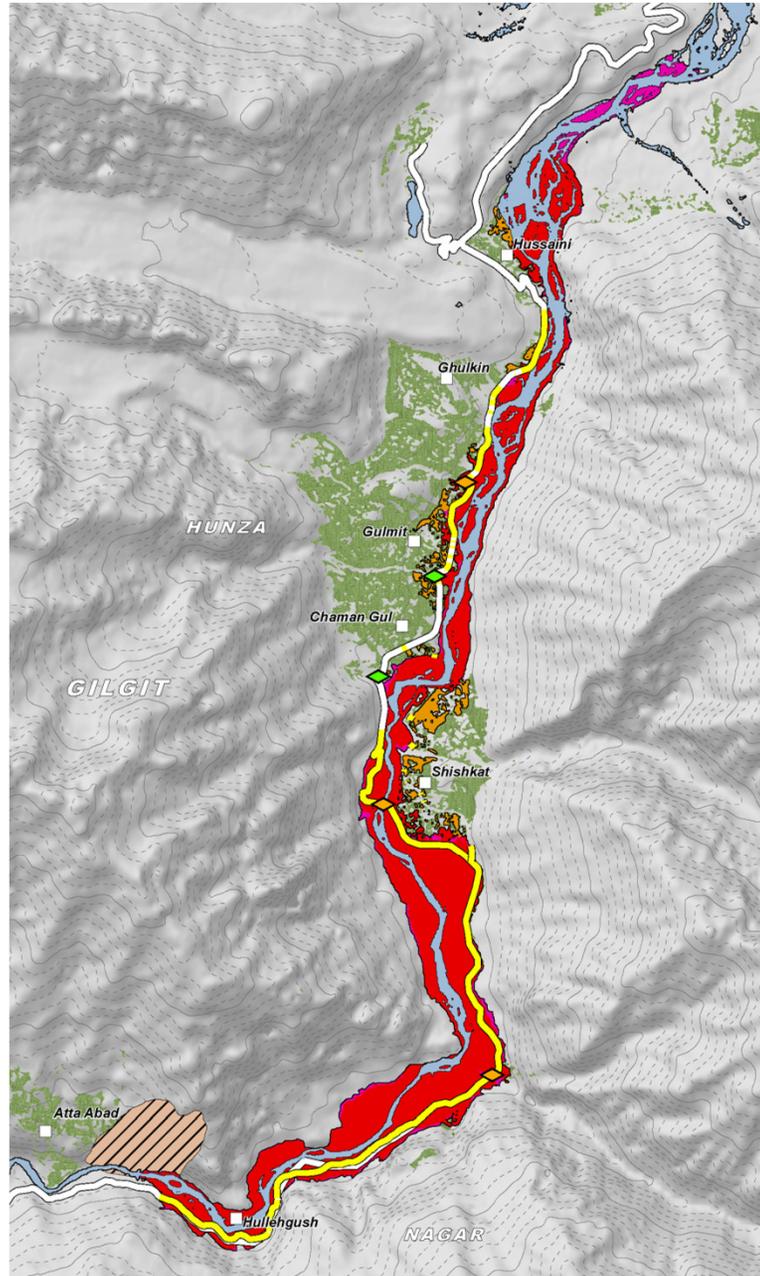
knowledge, diversity, innovation, sin. transfer, expertise, learning by doing, network, ship, skills building, ing, ext

**Legend**

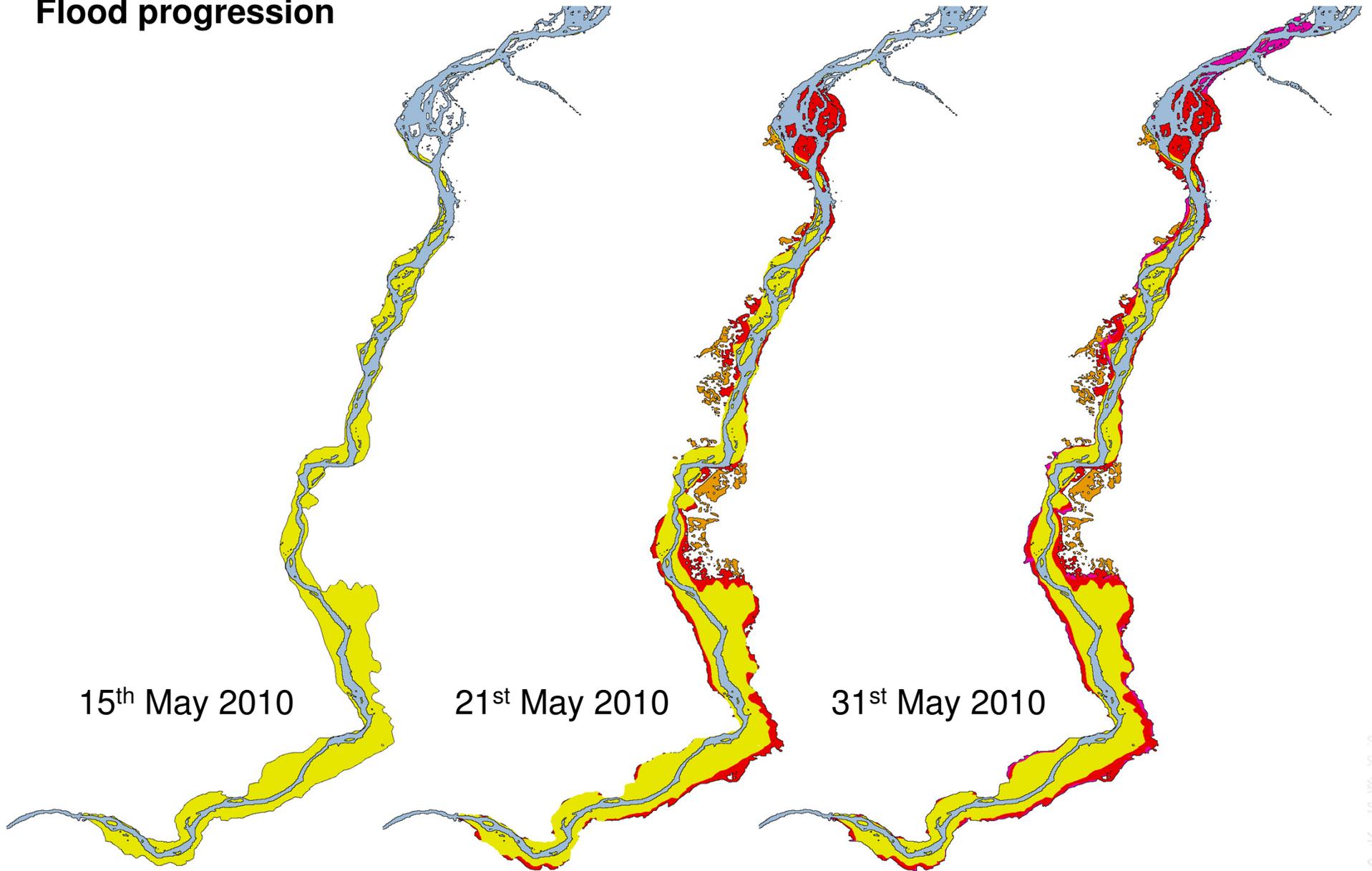
- ..... Village / Town      ✈ ..... Airfield
- ◇ ..... Bridge (likely functional)
- ◊ ..... Bridge (likely Flooded / Destroyed)
- ..... Likely Undamaged Segment of Karakoram Highway (KKH)
- ..... Likely Flooded Segment of Karakoram Highway (KKH)

**SATELLITE ASSESSMENT CLASSIFICATION:**

- ..... Probable Areas of Flood Water Expansion as on 31 May 2010
- ..... Potentially Flood-Affected Land as on 21 May 2010
- ..... Probable Flood Waters (Attabad Dam Lake) as on 21 May 2010
- ..... Pre-Landslide Hunza River Extent as on 10 September 2009
- ..... Cultivated Lands as on 10 September 2009
- ..... Ataabad Landslide Zone



# Flood progression



15<sup>th</sup> May 2010

21<sup>st</sup> May 2010

31<sup>st</sup> May 2010

diversity, lin. tran- learning, ship, sm- ing, t. s

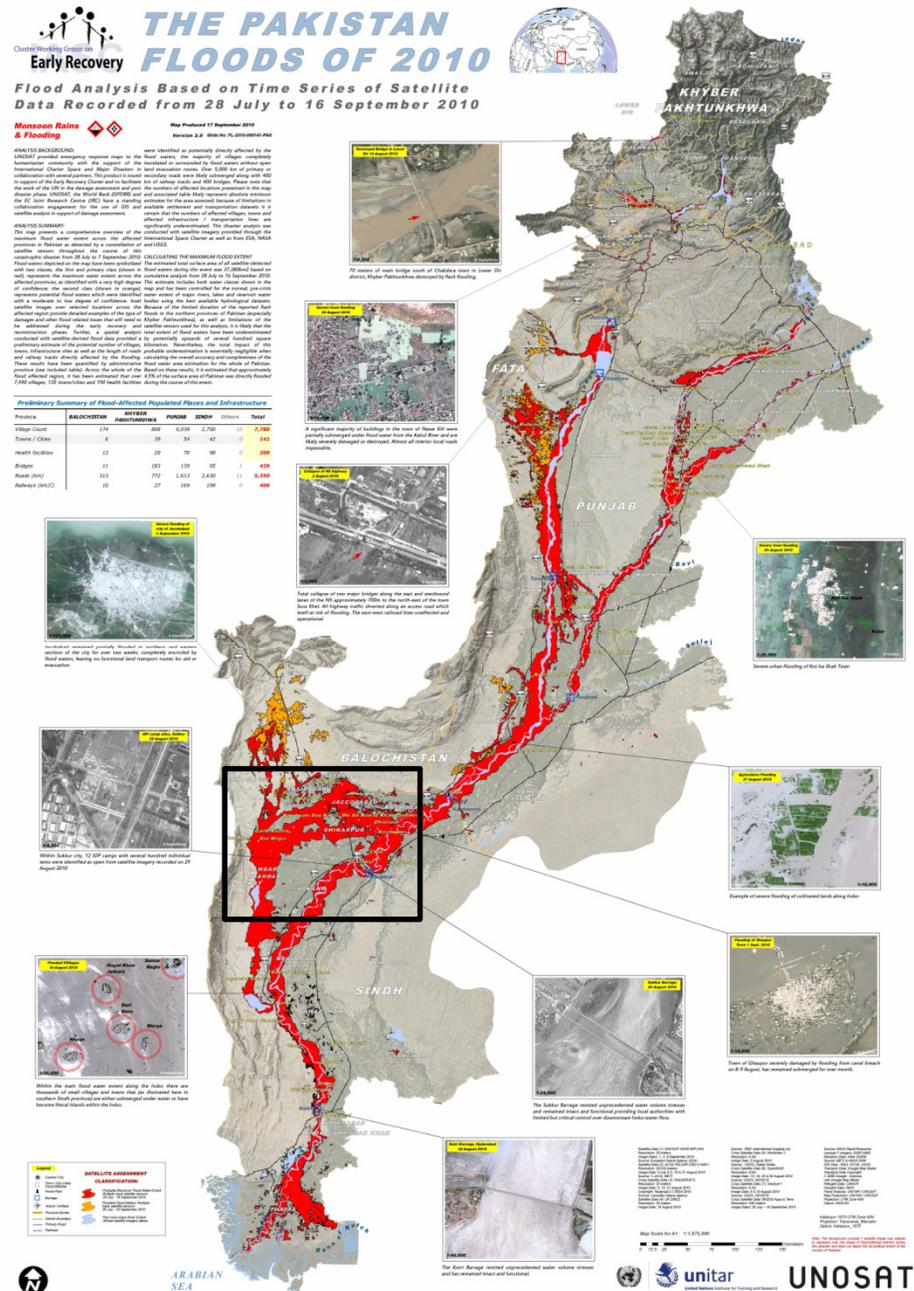
# Pakistan flooding 2010

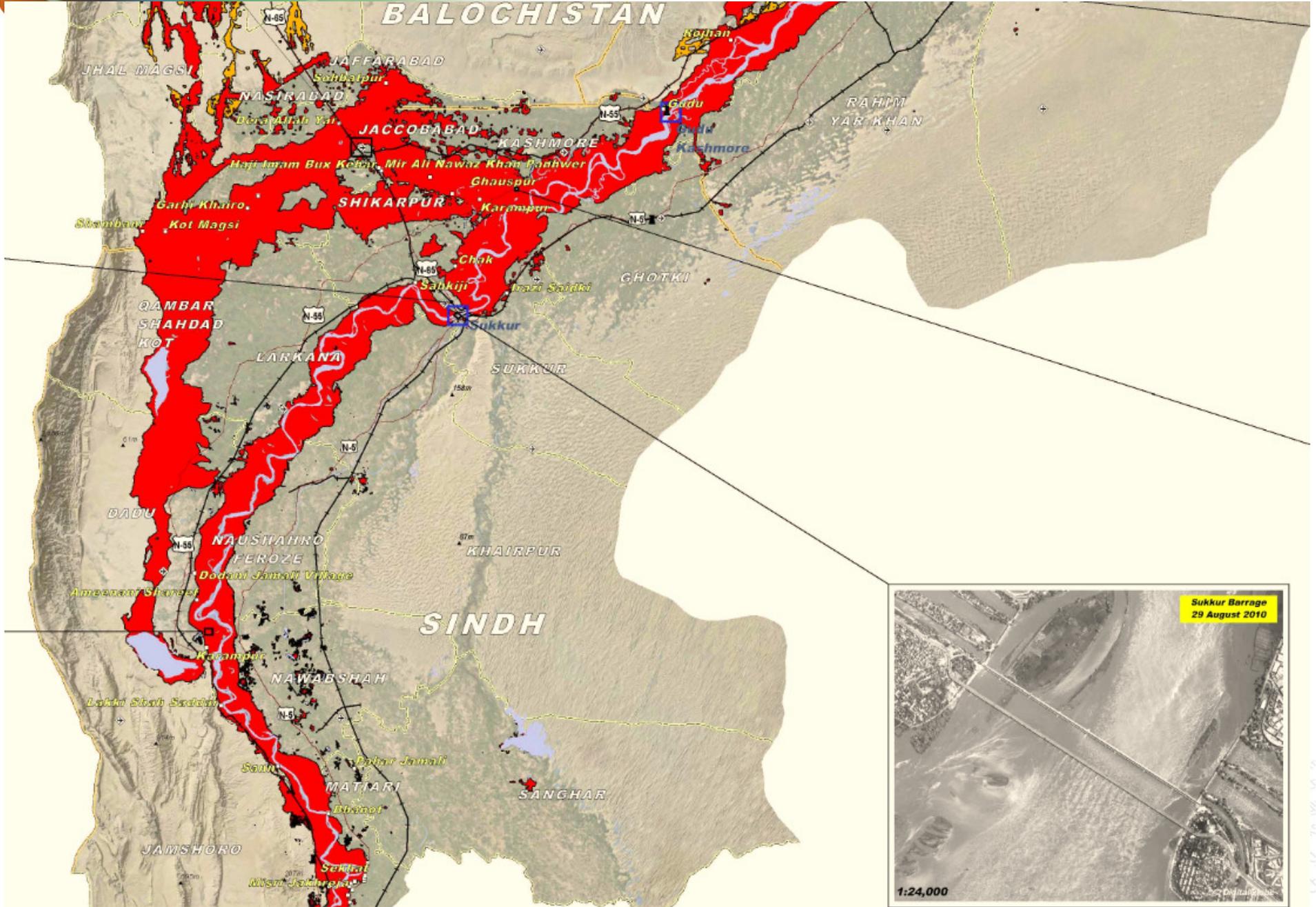
## Natural aspects

- Event start: End of July
- Heavy rainfall in northern Pakistan (Monsoon)
- Flood extents from Swath valley to the Arabic Sea
- More than 37.000 Km<sup>2</sup> of inundated land
- Precipitated Water > Carrying capacity of Indus River

## Operational aspects

- Multiscale analysis
  - MODIS, Radar, Optical
- Different scale products delivered to end users





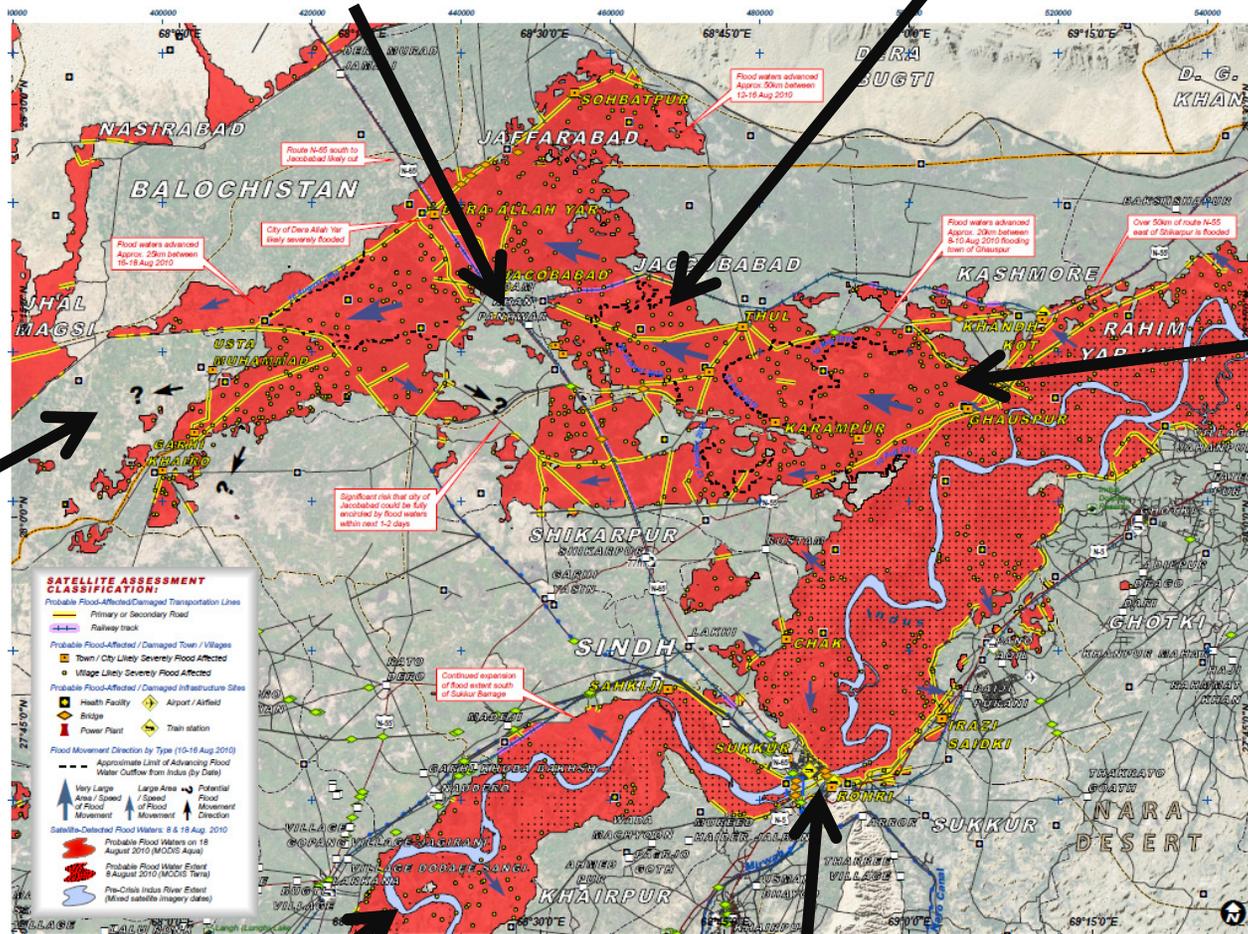
# Pakistan flooding 2010 – Human impact (18<sup>th</sup> August)

Progress within 10 days  
120 – 150km

Large Cities like Jacobabad are affected

Flood prognosis for the next day

Start of Water Overflow



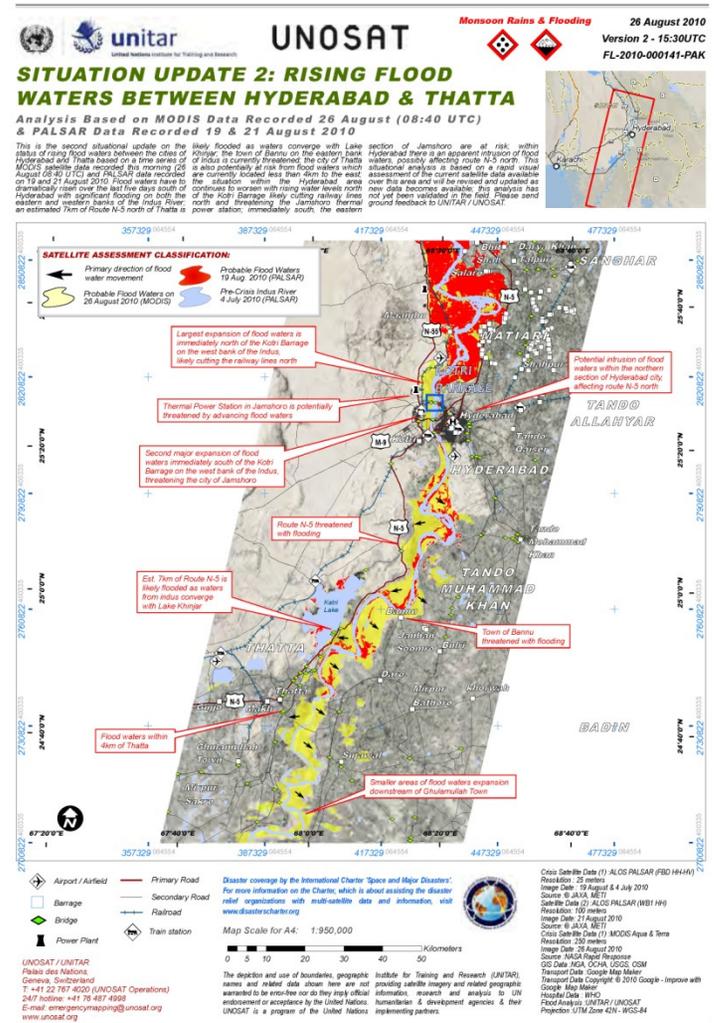
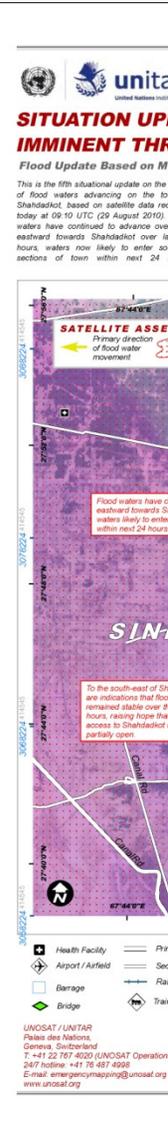
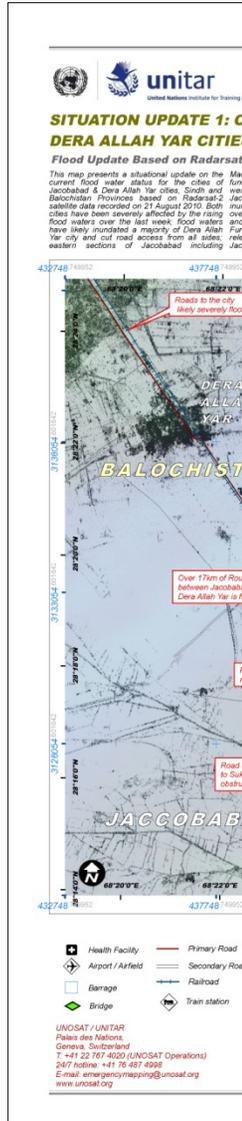
Flooding further downstream

Sukkur Barrage causes retaining water further upstream

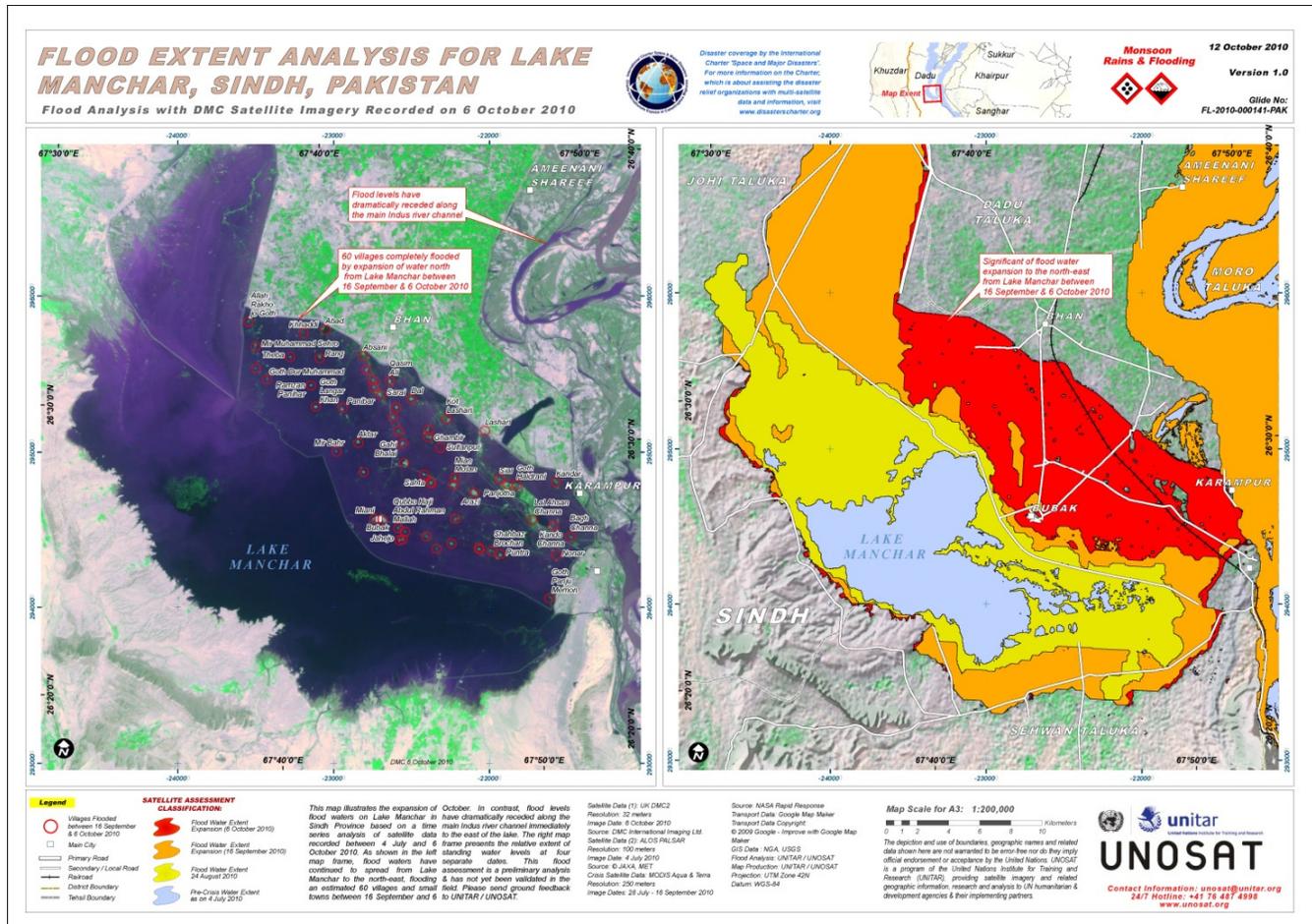
Participatory approach, research sharing, new technology, expertise, network learning by doing, skills building, etc.



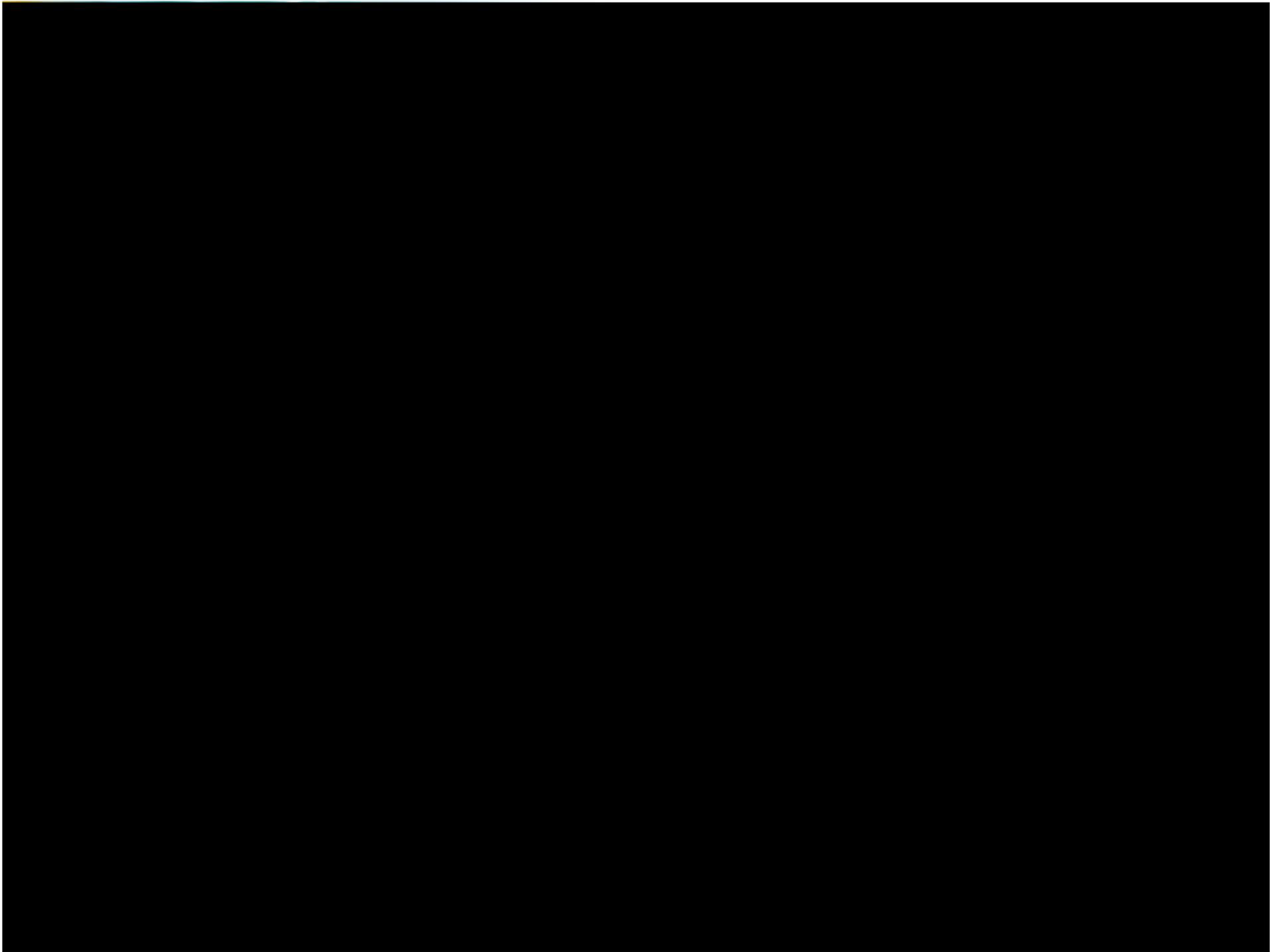
- **Highly dynamic flooding extent clearly required more rapid and diverse analysis report products**
- Multiple single page A4 “Situational Update” reports produced with satellite imagery usually acquired same day
- More focus on describing current status in near real time and even trying to estimate flood movement in next 48hrs

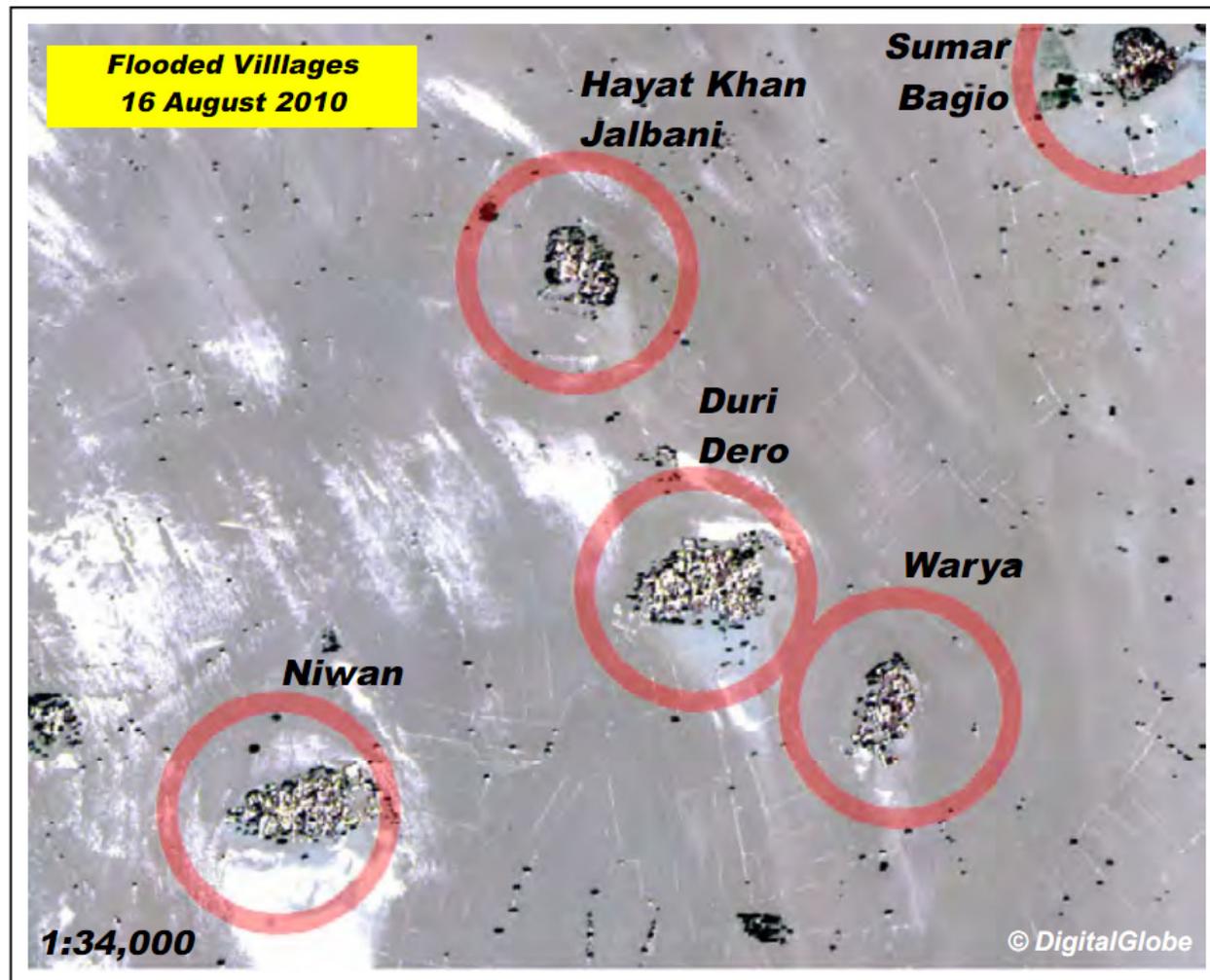


- 6) Comprehensive time series of flood datasets allowed additional products
- Final flood water analysis was conducted in October 2010 (Disaster started in late July!)



Knowledge, international, participation, university, innovation, knowledge sharing, research, transfer, expertise, new technology, learning by doing, network, skills building, ext

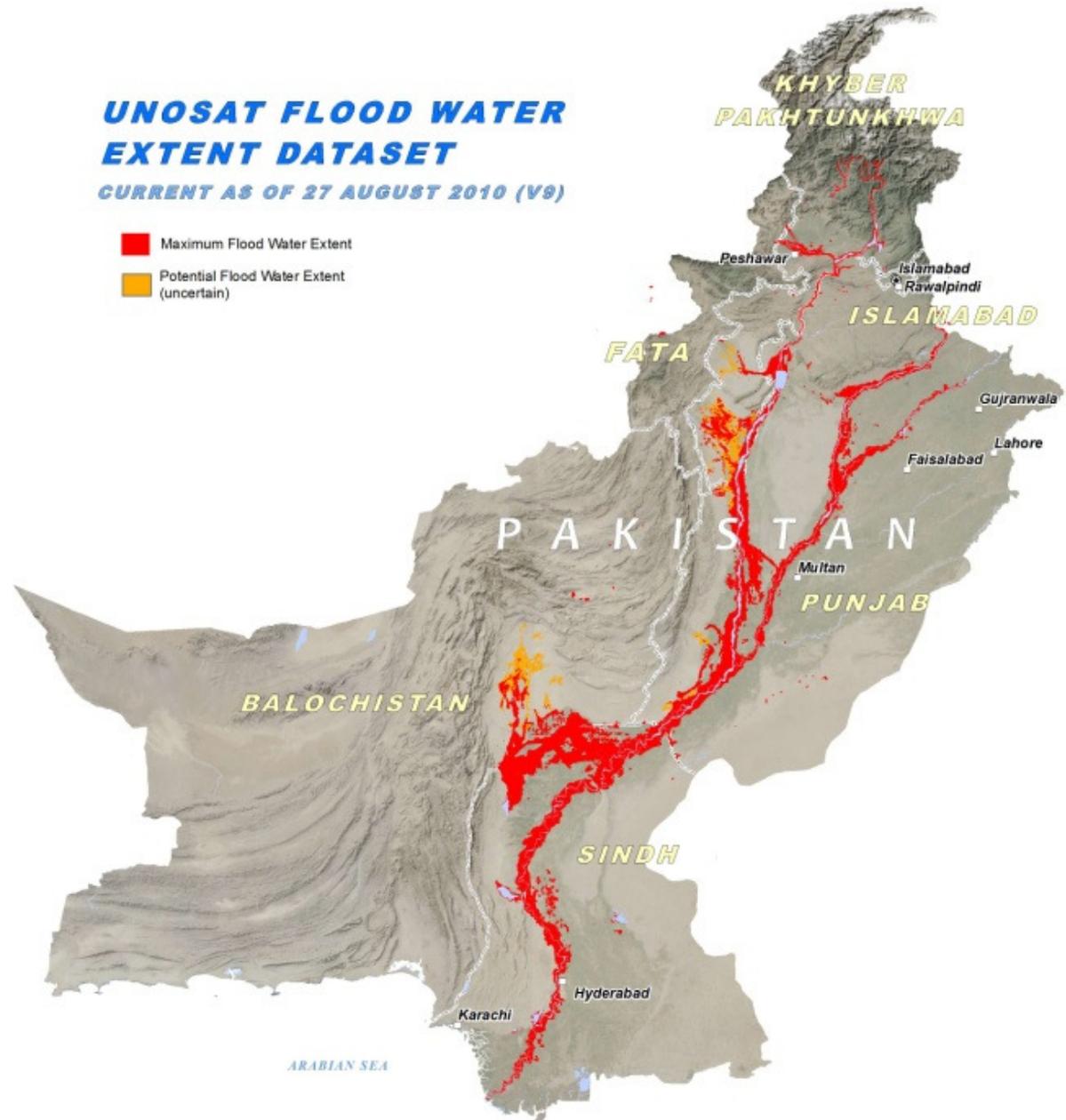




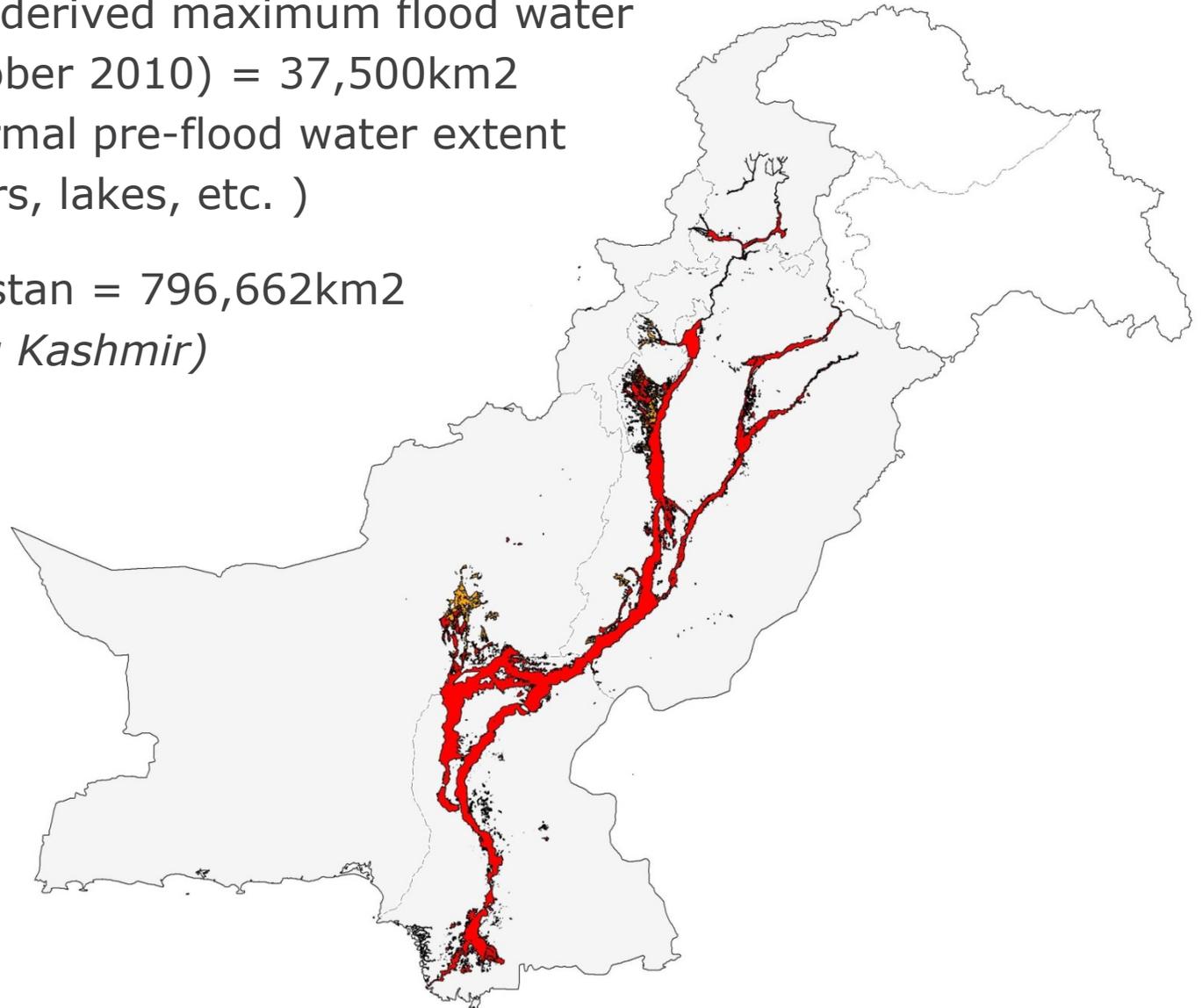
*Within the main flood water extent along the Indus there are thousands of small villages and towns that (as illustrated here in southern Sindh province) are either submerged under water or have become literal islands within the Indus.*

*Participatory approach, r  
Knowledge sharing, research  
Expertise, new technology  
ning by doing, network  
ship, skills building, ext*

- New Product type request from Local and international agencies for a **Cumulative Maximum Flood Water Extent**
- Dynamically combined all flood water extents from multiple dates and locations into a single dataset
- Continuously updated as flood waters moved further south inundating new areas over one month after start of disaster event



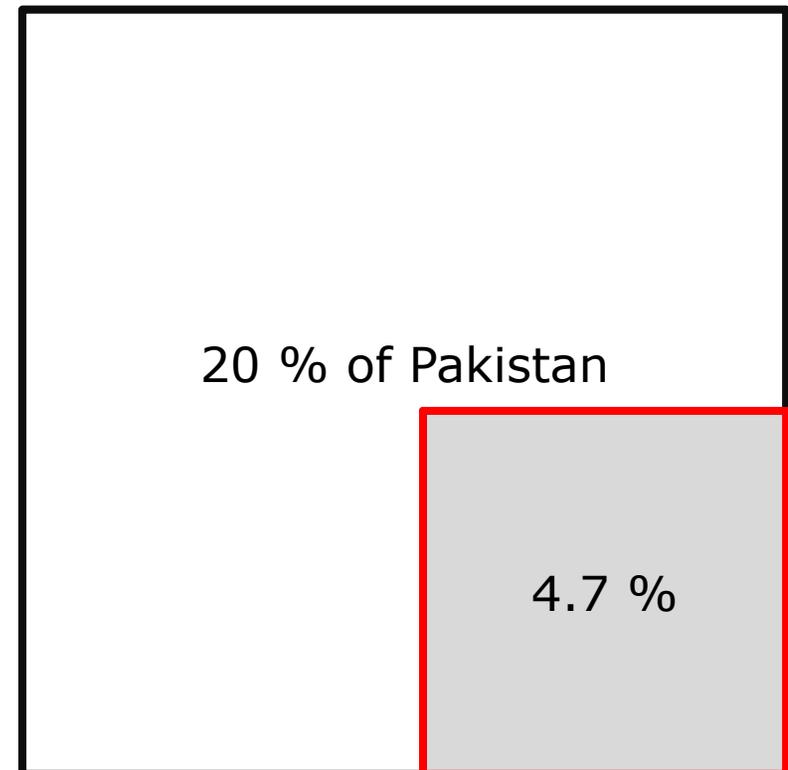
- UNOSAT Satellite-derived maximum flood water extent (July –October 2010) = 37,500km<sup>2</sup> (controlled for normal pre-flood water extent of rivers, reservoirs, lakes, etc. )
- Total area of Pakistan = 796,662km<sup>2</sup> (*excluding Jammu Kashmir*)



## Conflict between Media, Government and Satellite-Based Estimates of the Pakistan Flooding Extent:

- "20% or 1/5th of Pakistan"
- "As large as England"
- "approximately 130.000 Km<sup>2</sup>"

Total flood inundated area, within 5 weeks, is according to UNOSAT analysis **4.7%** of the country.



Relative comparison of inundated area

## Pakistan flooding 2010 Human impact

### GIS Analysis

- Cross-referencing with other data-sets allows more detailed analysis  
→ beyond natural impact
- Quantifying the impact on population is still difficult  
→ populated places are available but no accurate pop. Figures
- Also documenting the impact on infrastructure (bridges, roads, hospitals...)

### *Preliminary Summary of Flood-Affected Populated Places and Infrastructure*

Province	<i>BALOCHISTAN</i>	<i>KHYBER PAKHTUNKHWA</i>	<i>PUNJAB</i>	<i>SINDH</i>	<i>Others</i>	<i>Total</i>
<i>Village Count</i>	174	808	4,038	2,750	10	<b>7,780</b>
<i>Towns / Cities</i>	6	39	54	42	0	<b>141</b>
<i>Health facilities</i>	12	20	70	98	0	<b>200</b>
<i>Bridges</i>	11	183	139	95	1	<b>429</b>
<i>Roads (km)</i>	313	772	1,613	2,630	21	<b>5,350</b>
<i>Railways (km) □</i>	10	27	169	199	0	<b>406</b>

The screenshot shows a web browser window titled "GEO-PICTURES, Pakistan - Windows Internet Explorer". The address bar displays "http://cernunosat05.cern.ch/gp/Flex/PKN/index.html". The browser's Favorites bar includes "2011 Esri International Use..." and "UNITAR-UNOSAT". The page title is "GEO-PICTURES, Pakistan". The main content area features a map of Pakistan with flood extent data overlaid in blue. The map includes labels for "Quetta", "Baluchistan", "Pakistan", "Rajasthan", "Jaipur", "Sindh", and "Hyderabad". A video player overlay is positioned over the map, titled "flood in pakistan 2010/jafferabad/panhwer sanri". The video player shows a scene of a flooded area with a vehicle and people. The map interface includes navigation controls on the left, a scale bar (0 to 200 km), and coordinates (Latitude: 27.990740, Longitude: 74.789078). The bottom of the browser window shows "Done" and "Local intranet | Protected Mode: On".

- Flood extent data sharing

- Social media integration, improved understanding, validation

knowledge, international, laboratory approach, diversity, innovation, knowledge sharing, research, sin. transfer, expertise, new technology, learning by doing, network, ship, skills building, ect

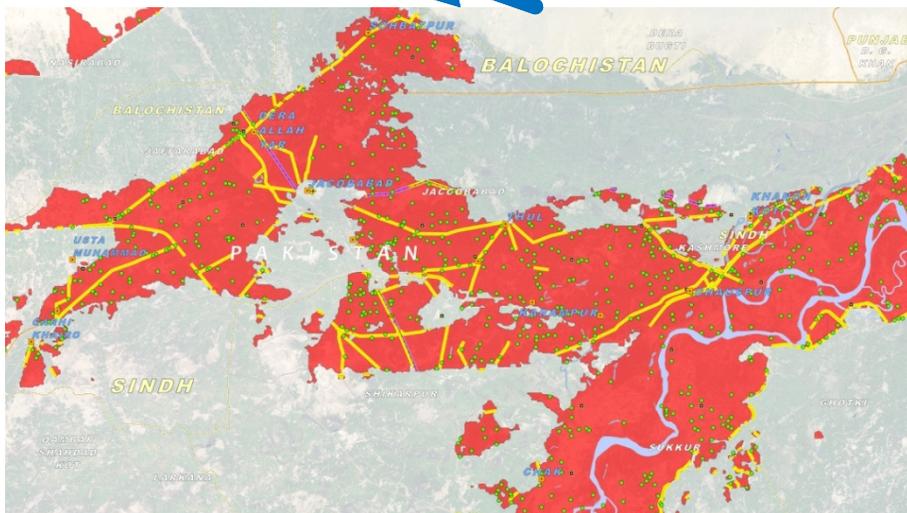
# Baseline geographic data combined with satellite imagery – Pakistan floods 2010



Google Map Maker Data for Pakistan



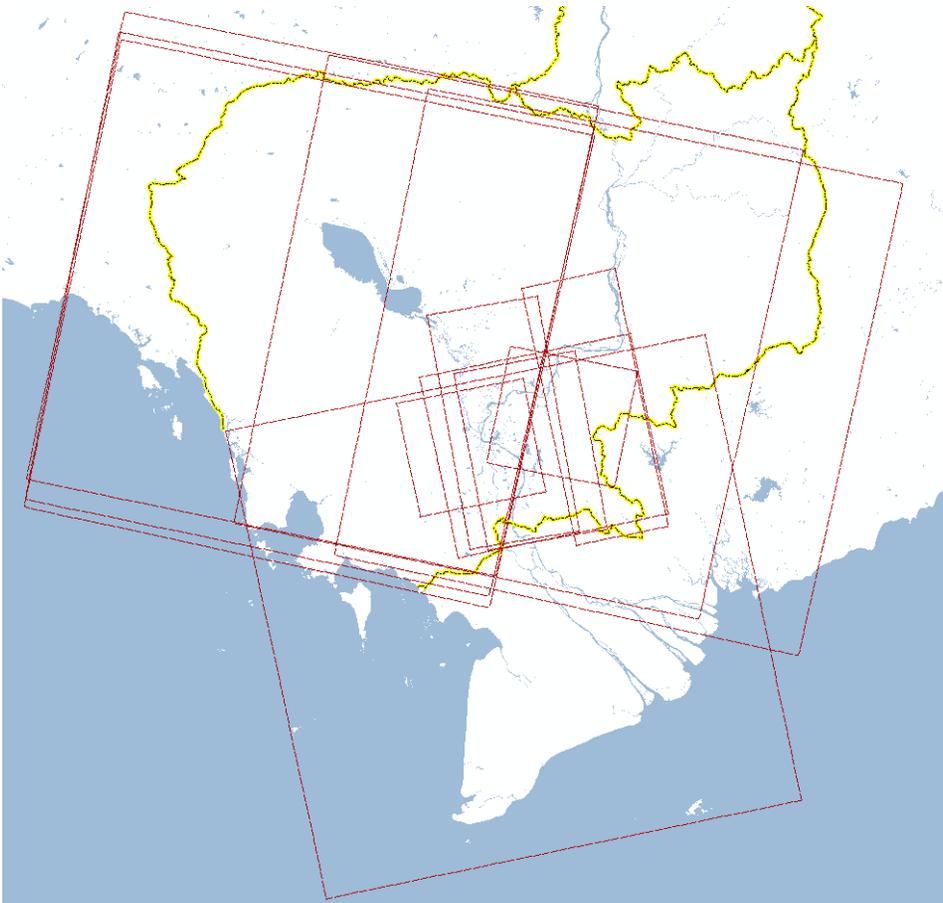
UNOSAT Flood Water Analysis



Impact: Detailed and comprehensive preliminary damage analysis, feedback into DRR



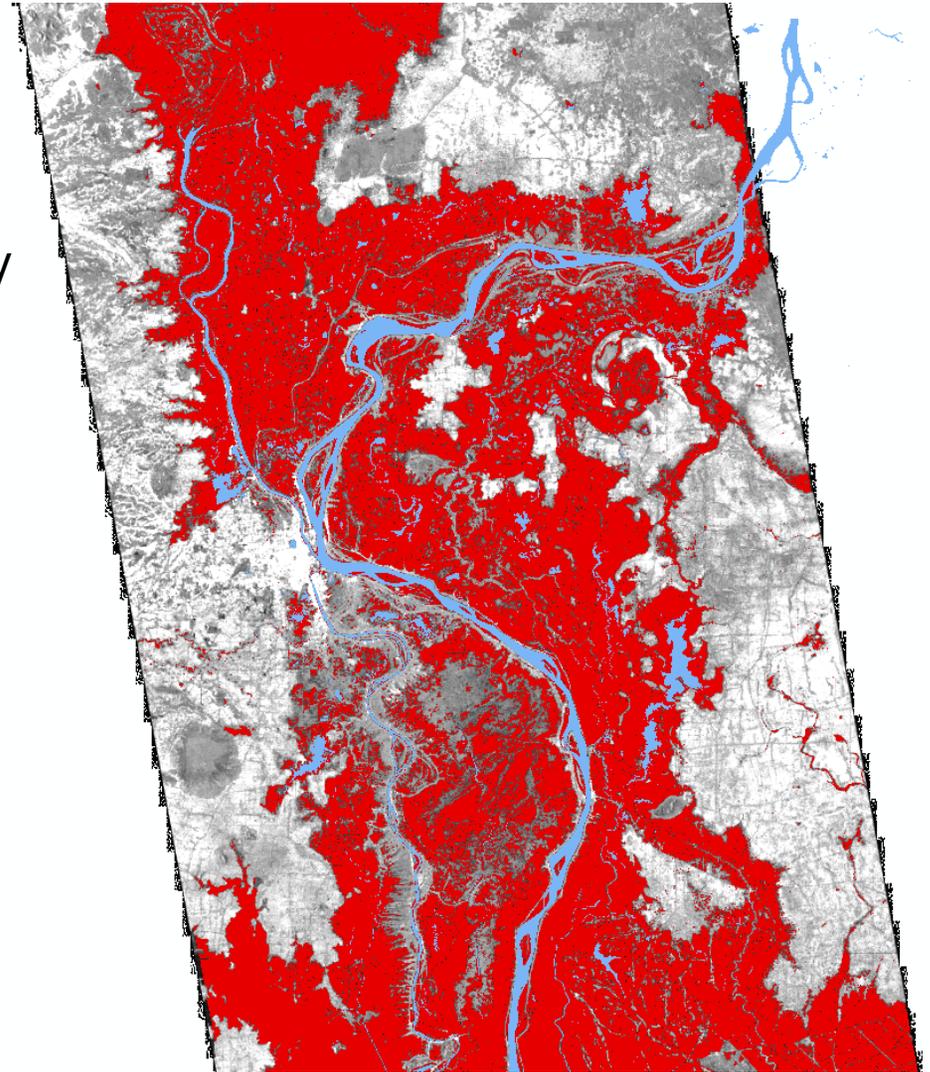
## Cambodia Flooding 2011



- Heavy seasonal rains caused severe flooding across
- Charter activated 12 October. Closed 9 November 2011
- Country wide monitoring over period of August – October 2011
- 12 Water extraction generated using; TX, ASAR IMP & WSM and Radarsat 1 & 2
- Imagery provided by Charter and other donors

Terrasar-X from 21<sup>st</sup> September 2011 →

- Multi-temporal analysis; disaster imagery & archive imagery
- Use of multiple sensors to get the fullest coverage of affected areas
- Scale of analysis covered a majority of Cambodia
- Deliverables given to end users were all vectors derived from imagery analysis



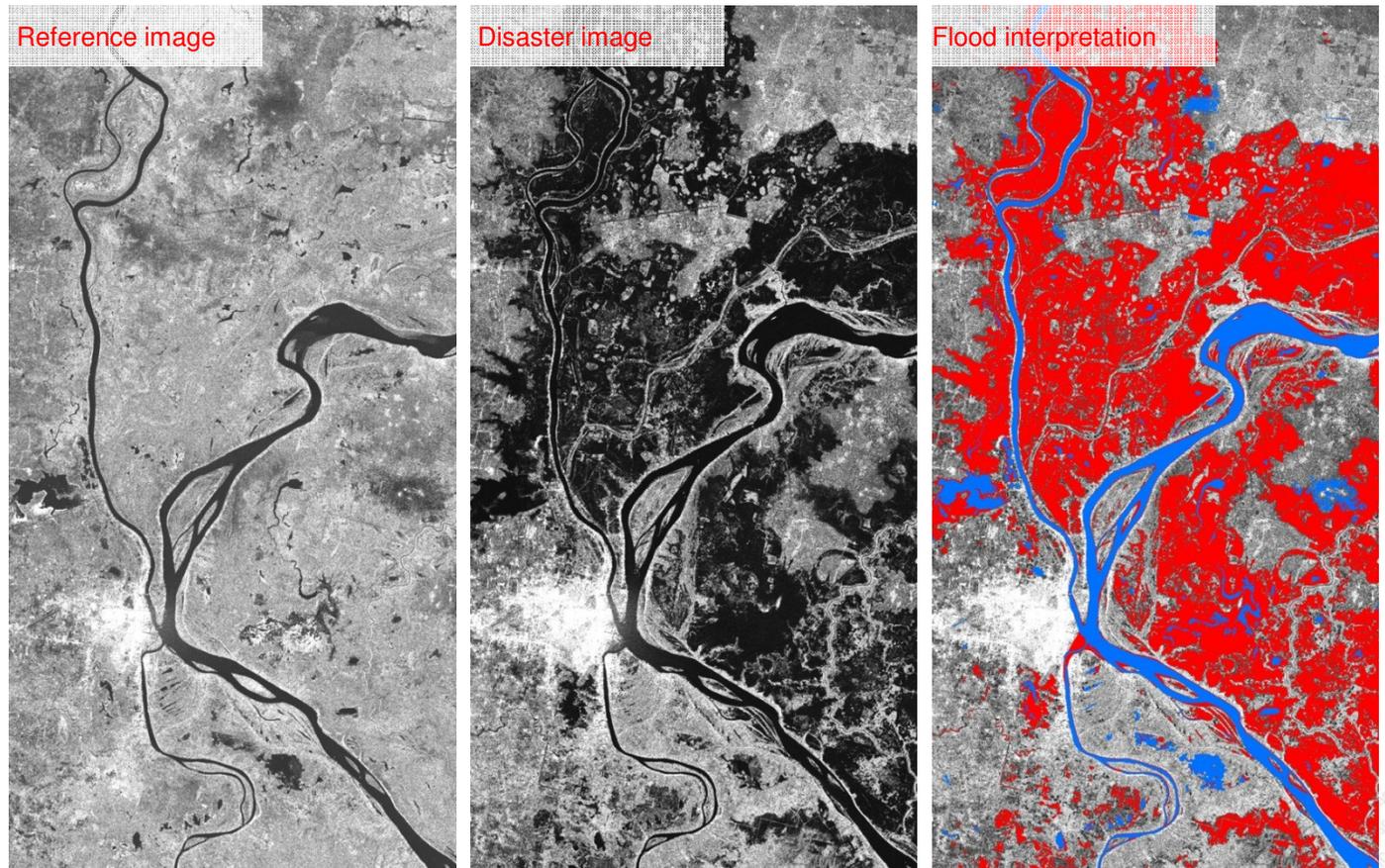
**Raster/Vector/Point output**

knowledge, innovation, participatory approach, sharing, research, diversity, innovation, expertise, new technology, transfer, learning by doing, network, ship, skills building, etc.

# Information from regional-scale images

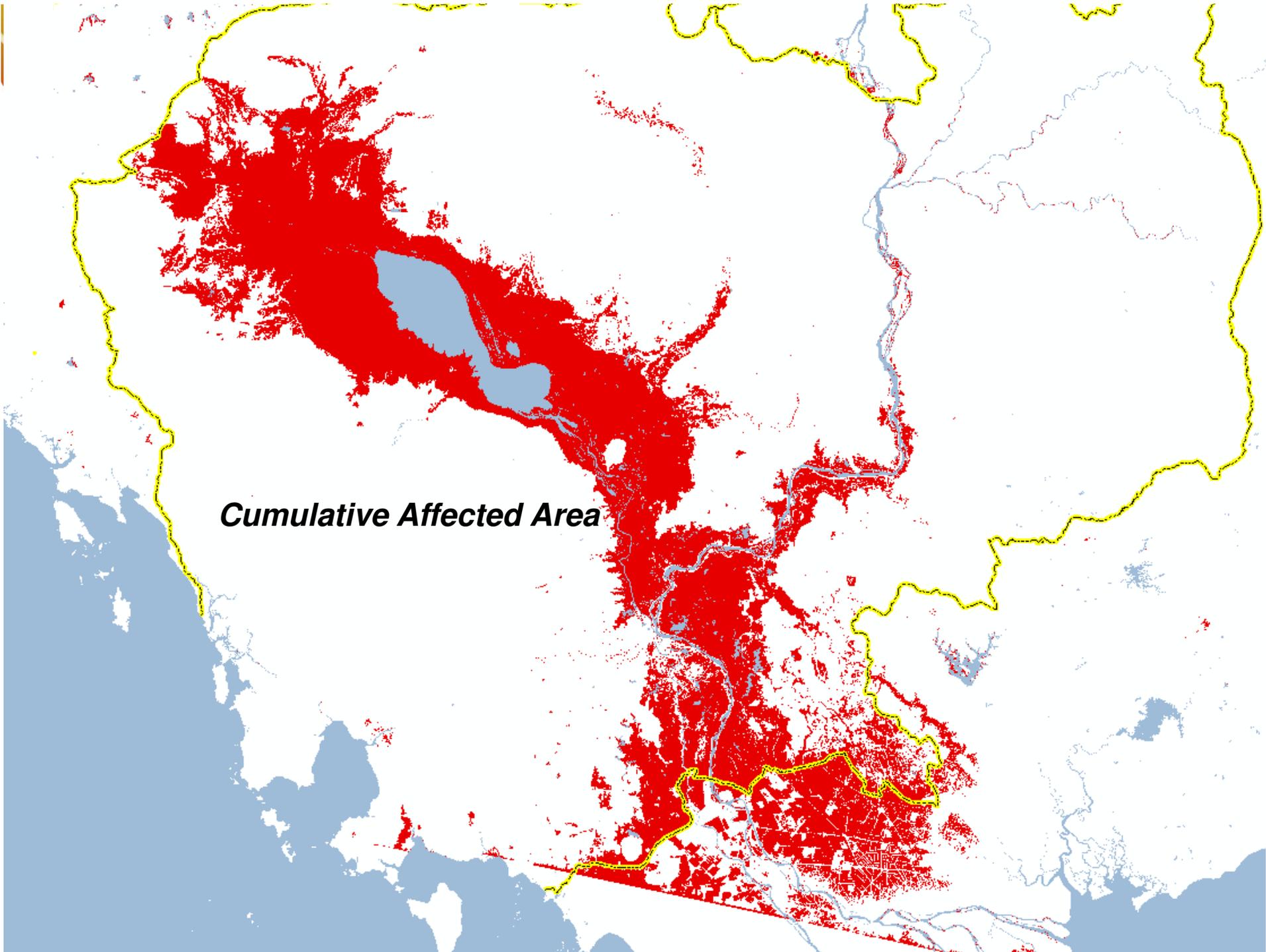
Mekong River (Cambodia), 2008-floods

Flood extent



RADARSAT

knowledge, international, knowledge, new technology, diversity, innovation, expertise, new technology, transfer, expertise, new technology, learning by doing, network, ship, skills building, ing, etc.



***Cumulative Affected Area***



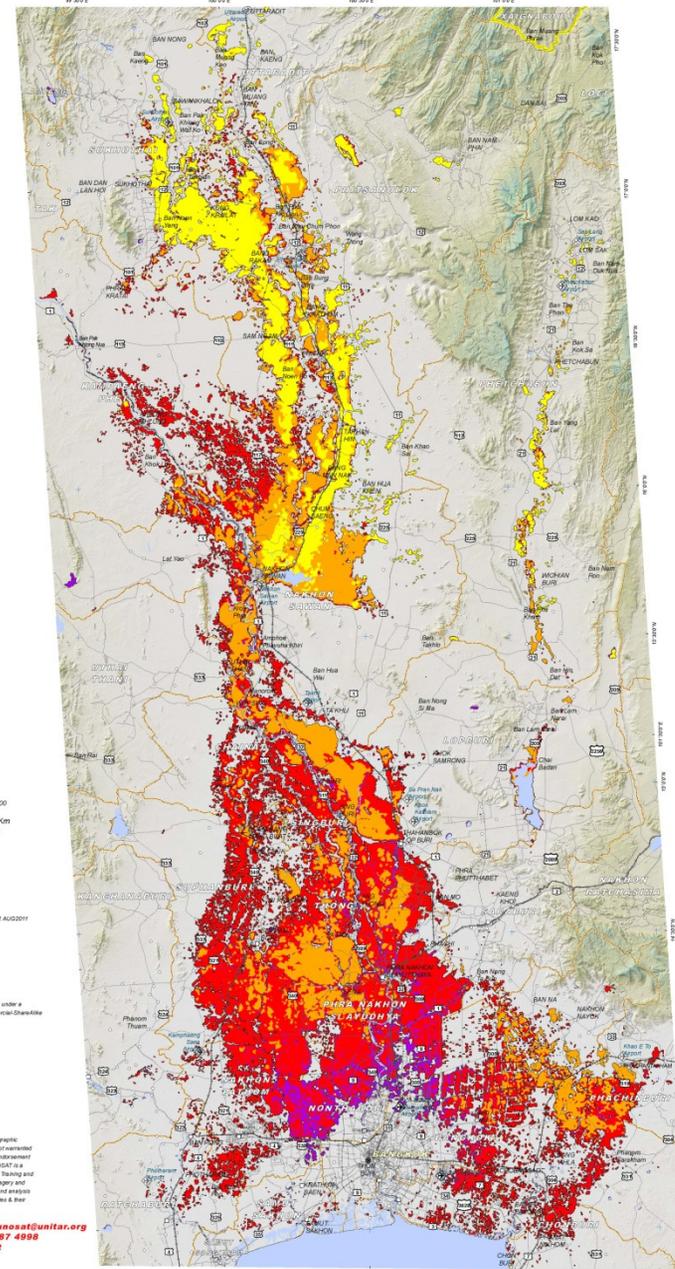
# TIME SERIES ANALYSIS OF THAILAND FLOODING 2011



Production Date:  
15/11/2011  
Version 1.0  
Glide Number:  
FL-2011-00135-THA

## Thailand floods 2011

- Near real time satellite image analysis and continued monitoring
- Multiscale & Multitemporal (similar to Pakistan analysis)
- Monitoring began from start of floods till they reached Bangkok
- SAR data not useful over Bangkok
  - Generated atlases with VHR optical imagery to fill the gaps
- Products used by national responders and UN



This map presents a time series analysis of the dramatic, southward progression of flood waters from the central provinces of Thailand towards the capital city of Bangkok based on satellite data recorded from mid-August to 14 November 2011.

Flood waters have been symbolized by color to represent the relative expansion of waters month to month. By mid-August flood waters were restricted to Northern provinces, symbolized in yellow. By mid-September, the flood waters rapidly expanded southward, symbolized in orange. By mid-October, flood waters had expanded dramatically in total area, effectively surrounding downtown Bangkok, while severely affecting most outlying populated areas.

As of 14 November 2011, flood waters have further risen into the central portions of the city, while receding very little in the north of the country, indicating that it will likely take several more weeks before an appreciable decline in standing flood waters is observed.

A more detailed review of very high resolution satellite imagery over Bangkok indicated that virtually all agricultural fields, significant stretches of major roads and highways as well as large residential areas remain inundated, leaving tens of thousands of residential homes and commercial businesses either partially or totally submerged.

It is likely that flood waters have been systematically underestimated along highly vegetated areas along main river banks, and within built-up areas within Bangkok because of the special characteristics of the satellite data used. This analysis has not yet been validated in the field. Please send ground feedback to UNOSAT/UNITAR.

Map Scale for A2: 1:900,000  
0 5 10 20 30 40 Km

Satellite Data: Envisat ASAR WS-HV  
Image Date: 12-26 October 2011  
Resolution: 150 m  
Source: European Space Agency  
Processed by: GeoPolymex A/S  
Satellite Data: MODIS Aqua & Terra  
Image Date: 14 NOV 23-5 SEPT 1822 AUGUST 07  
Resolution: 250 m  
Source: NASA  
Processed by: NASA Rapid Response  
Settlement Data: EU, JRC / IGDA  
Road Data: ECR, COM  
Other Data: COGSA, USGS  
Production: UNITAR / UNOSAT  
Analysis conducted with ArcGIS v10  
This work by UNOSAT/UNITAR is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.

Coordinate System  
WGS 1984 UTM Zone 47N  
Projection: Transverse Mercator  
Datum: WGS 1984  
False Easting: 500 000 0000  
False Northing: 0 0000  
Central Meridian: 105 0000  
Scale Factor: 0.9996  
Latitude Of Origin: 0 0000  
Units: Meter

The depiction and use of boundaries, geographic names and related data shown here are not guaranteed to be accurate nor do they imply official endorsement or acceptance by the United Nations. UNOSAT is a program of the United Nations Institute for Training and Research (UNITAR), providing satellite imagery and related geographic information, research and analysis to UN humanitarian & development agencies & their implementing partners.

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24/7 Hotline: +41 76 487 4998  
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- Legend**
- Major Towns/City
  - International Boundary
  - Town/Village
  - Province Boundary
  - Airport / Airfield
  - Primary Road
  - Secondary Road
  - Highway Line

- Flood Water Expansion Extent**
- Probable Flood Water Expansion: 15 November 2011
  - Probable Flood Water Expansion: mid-October 2011
  - Probable Flood Water Expansion: mid-September 2011
  - Probable Standing Flood Waters: mid-August 2011
  - The Crisis Water Extent (Landsat)



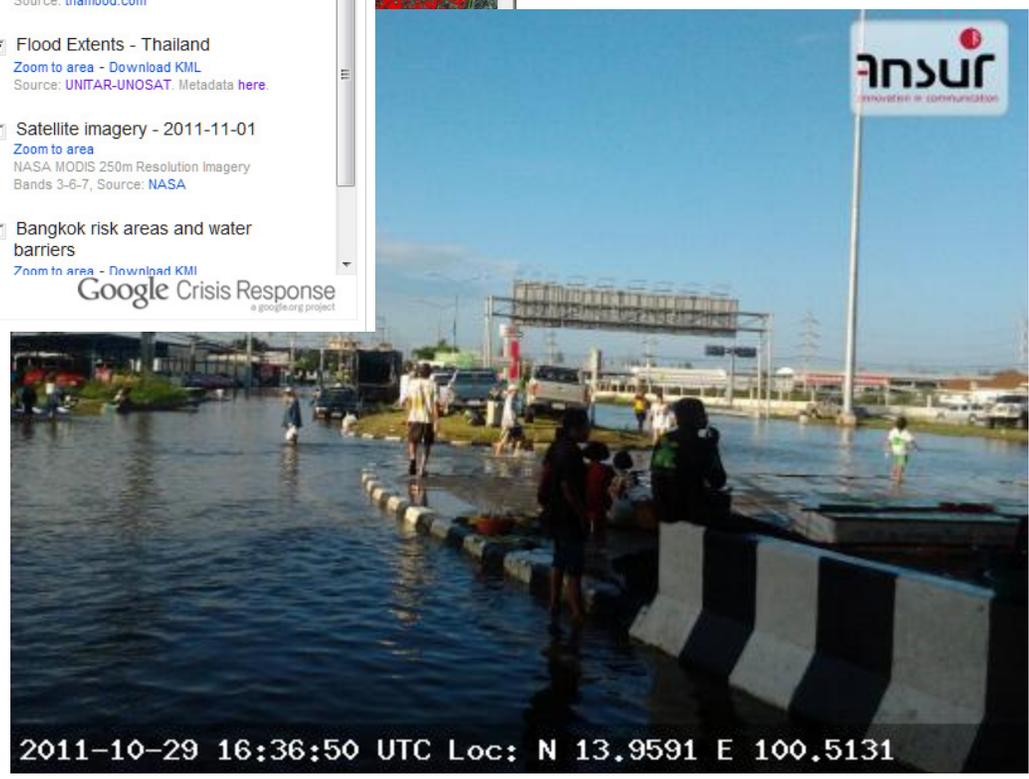
The screenshot shows the GEO-PICTURES web interface. The main map displays a satellite view of Thailand with red areas indicating flood extent. A sidebar on the right contains several layers:
 

- Zoom to area**: GeoEye-1 50cm Imagery, Source: GeoEye
- Severely affected area: Urgent help needed**: Zoom to area - Download KML, Source: thaiflood.com
- Flood affected areas across Thailand**: Zoom to area - Download KML, Source: thaiflood.com
- Flood Extents - Thailand**: Zoom to area - Download KML, Source: UNITAR-UNOSAT. Metadata here.
- Satellite imagery - 2011-11-01**: Zoom to area - Download KML, NASA MODIS 250m Resolution Imagery Bands 3-6-7, Source: NASA
- Bangkok risk areas and water barriers**: Zoom to area - Download KML

 The interface also includes a 'Free photo app' button and a 'Google Crisis Response' logo at the bottom of the sidebar.



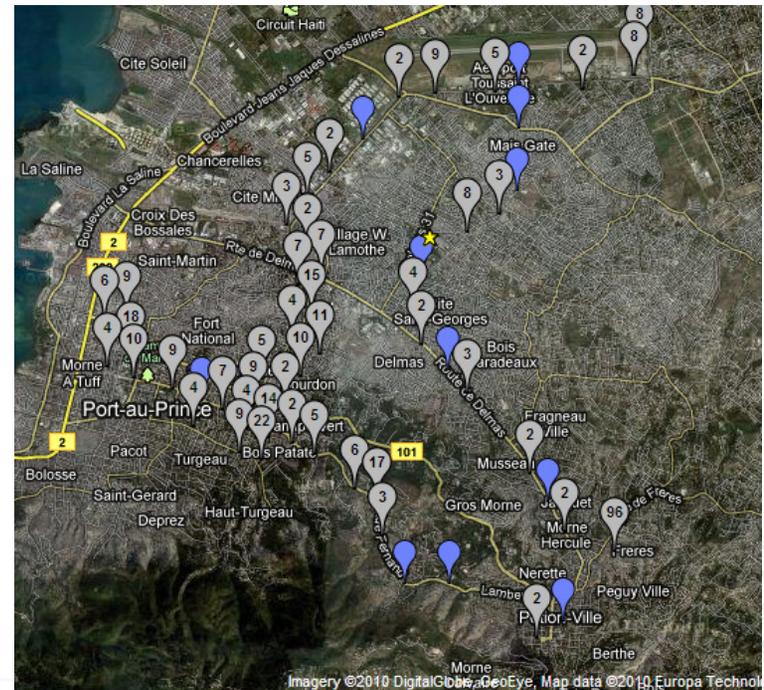
- **Sharing of flood extent vectors**
- **Crowd-sourced geo-photo display using ASIGN Android app**
- **UNOSAT in field**



2011-10-29 16:36:50 UTC Loc: N 13.9591 E 100.5131

# geopictures

- Automatic geo-positioning and mapping of photos, videos, text, voice (Android+)
- Cost-efficient solutions (smart compression)
- Tested in exercises, used in Haiti, Nigeria, Pakistan, Thailand
- GPS cameras, mobile phones (Android, iPhone)



**Download the ASIGN Android App**



**[www.geo-pictures.eu](http://www.geo-pictures.eu)**

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*Thank you for your kind attention!*

# Questions?

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Your questions

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