



Institute of Remote Sensing and Digital Earth  
Chinese Academy of Sciences

# Protecting World Heritage from Natural Hazards through Earth Observation Technology

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# Impact may disasters have on World Heritage



- Global climate change is also exposing World Heritage natural properties and the ecological systems that sustain life to increasing disaster risks.
- Disasters pose risks not only to the physical attributes that carry the heritage values of the property, but also to the **lives of visitors, staff and local communities** living on the site or in neighboring areas, and also to important collections and documents.

# Impact may disasters have on World Heritage



**Bam (Islamic Republic of Iran) due to earthquake in 2003**



**Before**



**After**

# Impact may disasters have on World Heritage



**Bam (Islamic Republic of Iran) due to earthquake in 2003**



# Impact may disasters have on World Heritage



**Bam (Islamic Republic of Iran) due to earthquake in 2003**



# Impact may disasters have on World Heritage



- **UNEVEN SETTLEMENT OF LAND AND LAND SLIDE IN HILLS**



**WALL CRACKS**



**STRUCTURAL CRACKS – BADRINATH TEMPLE FACADE**



**After**

# Impact may disasters have on World Heritage



## Edinburgh Old Town Fire - December 2002



# Impact may disasters have on World Heritage



Temple of the Tooth Relic in Kandy (Sri Lanka) after terrorist attack in 1998



# Why Protect Heritage?

- **Heritage drives sustainable development and local economies**
- **Disasters are driving losses to heritage**
- **Climate change and conflicts threaten heritage**
- **Heritage contributes to resilience**
- **Heritage is not being sufficiently protected**

# Why Protect Heritage?



## Heritage drives sustainable development and local economies

Cultural heritage is also a powerful asset for inclusive **economic development**, by **attracting investments and promoting green, locally based, stable and decent jobs** related to a wide range of sustainable activities in areas such as **tourism, conservation, construction, food production, traditional healing and, the production of crafts of all kinds and the arts** in general.

In Europe, for instance, heritage is vital to the competitiveness of tourism, which is valued **at 586 billion euros (€)** per annum and employs **9.7 million people**.



Rice Terraces of the Philippine Cordilleras

# Why Protect Heritage?



## Disasters are driving losses to heritage

- Heritage is exposed to a number of threats from urbanization, development pressures, socio-economic transformations, unsustainable tourism and lack of resources.
- The impact of disasters on heritage can also be severe. More cultural heritage is lost in disasters than is ever fully accounted.

# Why Protect Heritage?



## Disasters are driving losses to heritage



**Damage to one of the turrets at the Castle of Ferrara during the earthquake in 2012, Italy.**

# Why Protect Heritage?



**Disasters are driving losses to heritage**



**Earthquake damage  
to the Catholic  
Basilica in  
Christchurch, New  
Zealand**

# Why Protect Heritage?



## Disasters are driving losses to heritage

**Damage to Cultural  
Heritage in Leh,  
India due to Cloud  
Burst in 2010**

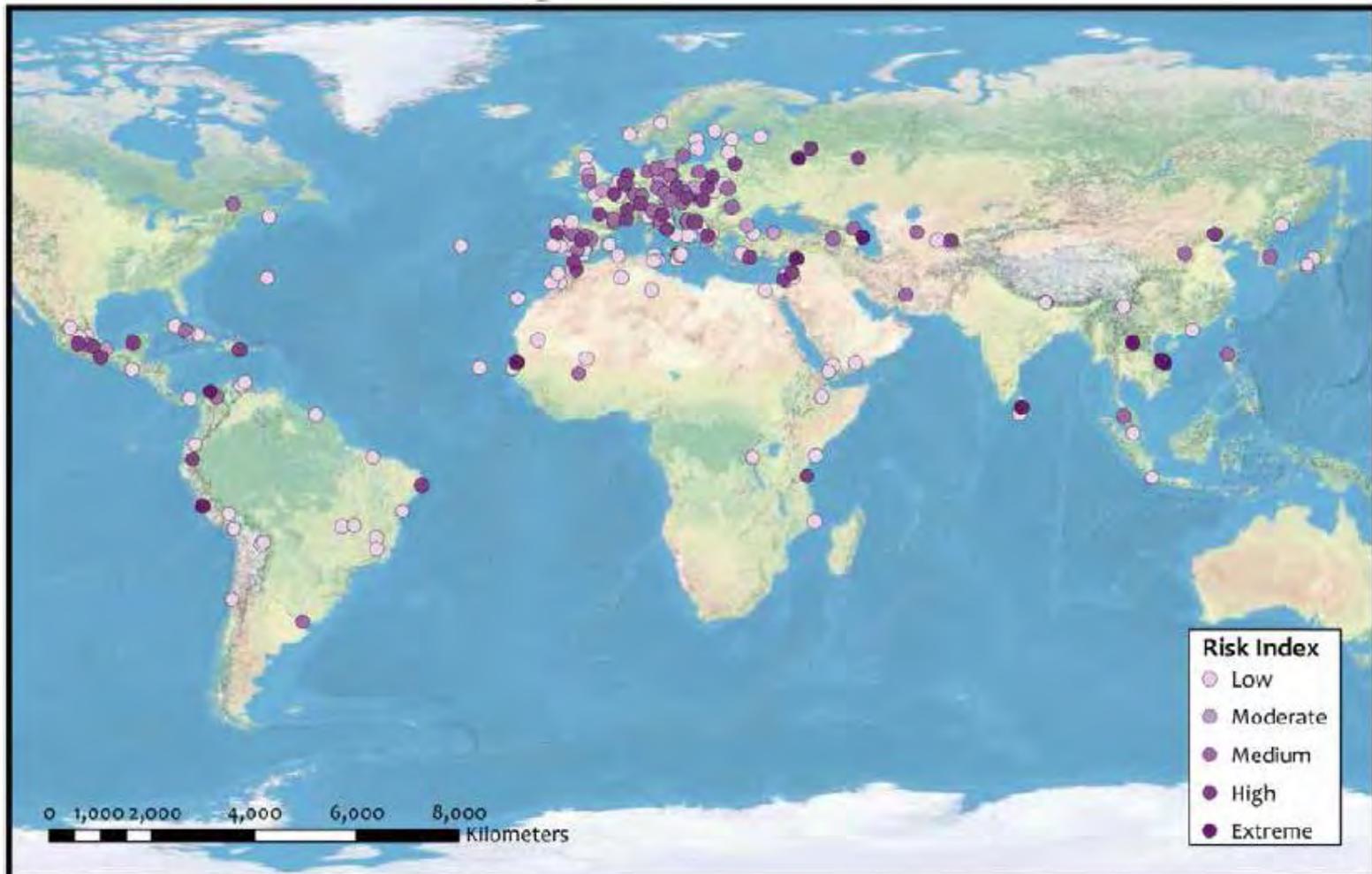


# Why Protect Heritage?



**Disasters are driving losses to heritage**

**Flood Risk to World Heritage Cities**

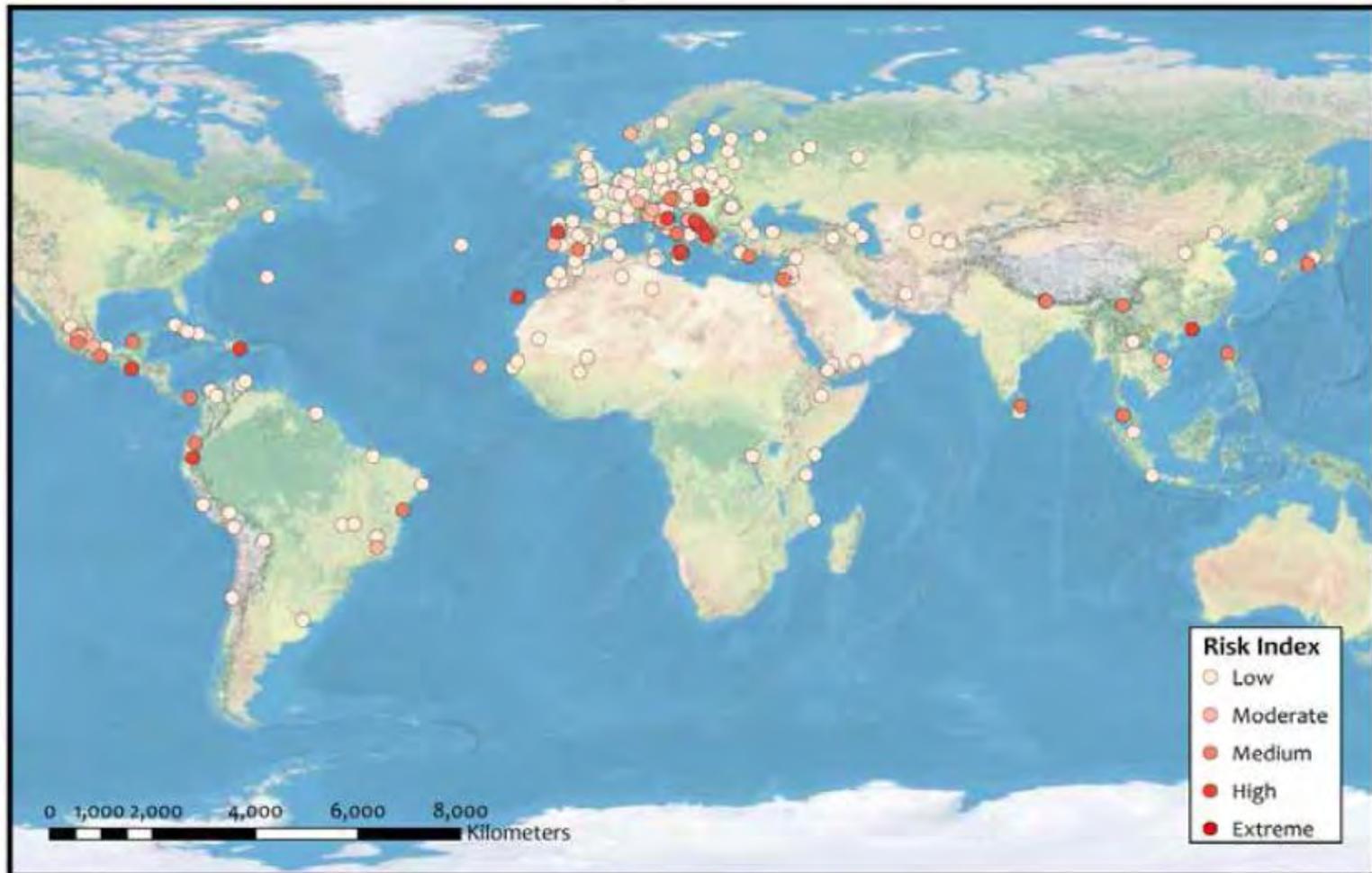


# Why Protect Heritage?



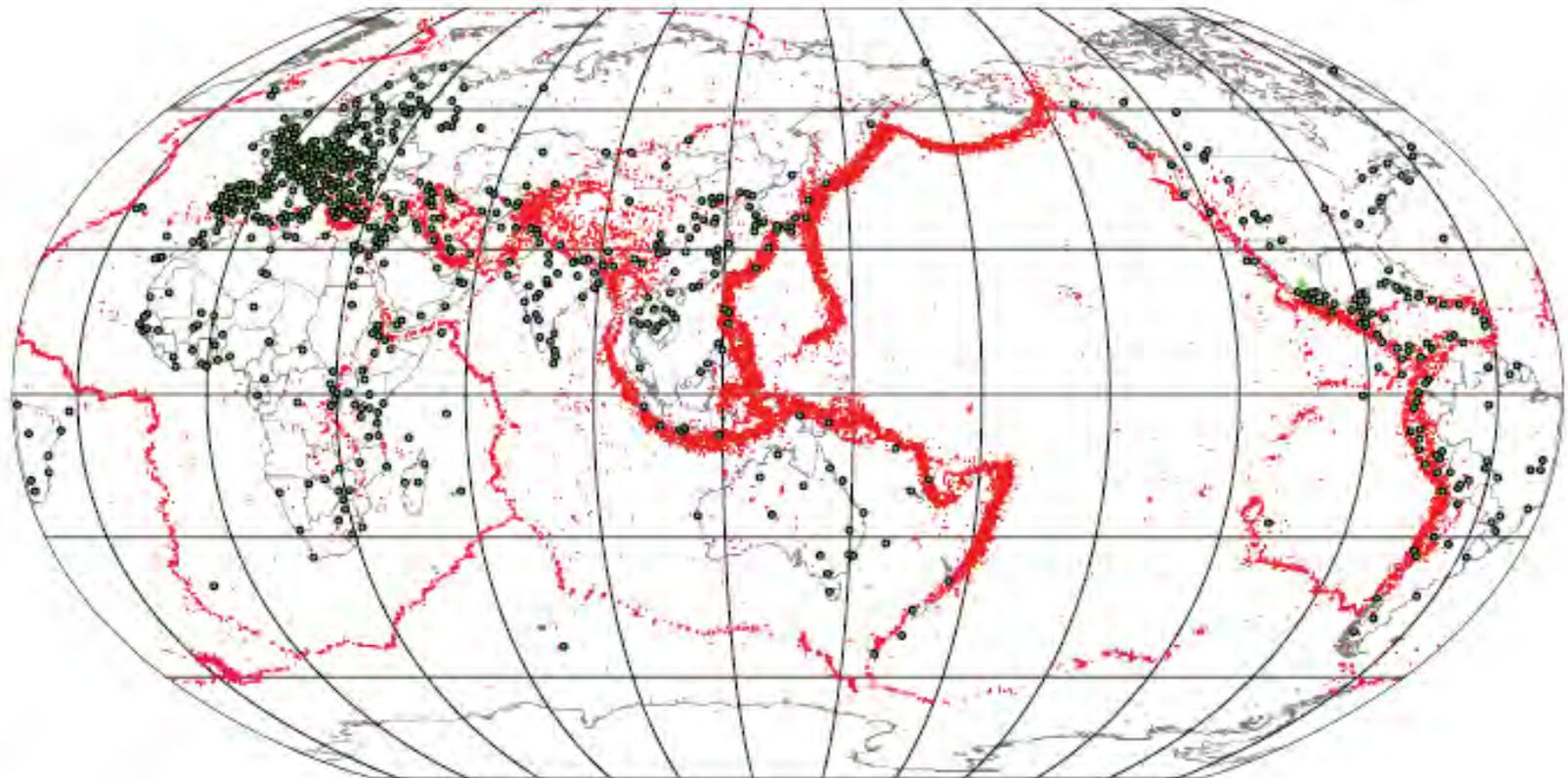
## Disasters are driving losses to heritage

### Landslide Risk to World Heritage Cities



# Why Protect Heritage?

Disasters are driving losses to heritage



**WORLD HERITAGE SITES (JUNE 2008)  
LOCATED IN THE EARTHQUAKE ZONES**

by Research Center for Disaster Mitigation of Urban Cultural Heritage,  
Ritsumeikan University, Kyoto, Japan

- Earthquake
- Cultural and Mixed Heritage
- Natural Heritage

# Why Protect Heritage?



## Climate change and conflicts threaten heritage

A survey was launched by the World Heritage Centre among all States Parties to the World Heritage Convention to assess the extent and nature of the impacts of climate change on World Heritage properties.

A total of **125 World Heritage sites** were mentioned specifically as threatened by climate change.

# Why Protect Heritage?



## Climate change and conflicts threaten heritage

**Conflicts and political tensions** often have a disastrous impact on heritage sites.



The Citadel at Aleppo, Syria has suffered major damage due to ongoing conflict.

# Why Protect Heritage?



## Climate change and conflicts threaten heritage

**Repair work at Timbuktu, Mali.**

**The World Heritage site has  
suffered significant damage  
during civil unrest**



# Why Protect Heritage?



## Heritage contributes to resilience

- In the same way that biological diversity increases the resilience of natural systems, cultural diversity has the capacity to increase the resilience of social systems.
  
- Traditional construction technologies that have evolved through trial and error are often very resilient because of indigenous knowledge that has enabled these technologies to manage local hazards and use local materials.

# Why Protect Heritage?



## Heritage contributes to resilience

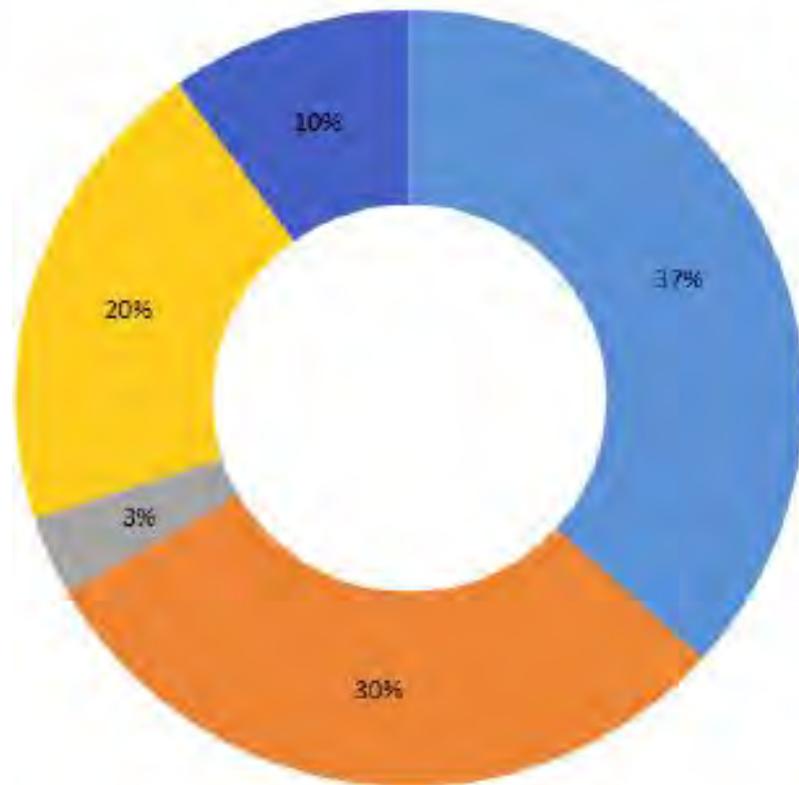
Traditional 'Bhunga' dwellings in Gujarat, India survived 2001 earthquake



# Why Protect Heritage?



## Heritage is not being sufficiently protected



- The cases where the risks were not identified within the management documents
- The cases where even though risks were identified, there was no concrete plan or any reference to mitigating these in the management systems established for the properties
- The cases where the risks were identified but mitigation included was considered mainly for visitor safety and not the properties themselves
- The cases where the risks were identified and plans to mitigate these were considered, but where the mitigation was not extensive enough or where there were concerns as to the effective implementation of such plans.
- The cases where both risks and mitigation of these were presented in an effective and extensive Risk Preparedness Plan.

# Disaster Risk Management for heritage



- DRM aims **to prevent or reduce the negative impacts** of disaster on World Heritage properties.
- The values for which the property was inscribed on the World Heritage List should be the foundation on which all other plans and actions are based (**all other plans for Heritage** ).
- DRM for heritage is concerned not only with protecting the property from major hazards but also with **reducing underlying vulnerability factors**.
- The risks to cultural and natural heritage that DRM must address may **originate inside the property or in the surrounding environment**.

# Disaster Risk Management for heritage



## DRM plan linked to the site management plan of a heritage property



**Lack of coordination** between the **site management systems** for the particular heritage property and the organizational set-up, policies and procedures for **disaster management in the city** or region in which the property is located.

# Analyze the factors that may cause disaster risks to your property



**Step 1**

**Step 2**

**Step 3**

**Step 4**

# Analyze the factors that may cause disaster risks to your property



## Step 1 - List natural and human-induced

**Listing all the natural and human-induced hazards that expose the property to disaster risks.** These would include primary hazards with potentially disastrous impact, such as earthquakes, as well as slow and progressive secondary hazards, or underlying risk factors, such as **changes in natural vegetation due to rising ground water or changes in ground water quality due to pollution.**

# Analyze the factors that may cause disaster risks to your property



## Step 2- Identify vulnerability factors

Identifying the processes that might, in combination with a primary hazard, cause disaster risk to the property.

- evaluating the **performance of existing management systems** and **disaster preparedness measures**
- analyzing the potential negative impacts of **existing damage and deterioration patterns or phenomena**
- analyzing the **underlying risk factors** relating to the **surrounding environment** that increase the property's vulnerability
- analyzing the potential negative effect of **poor restoration done in the past.**

# Analyze the factors that may cause disaster risks to your property



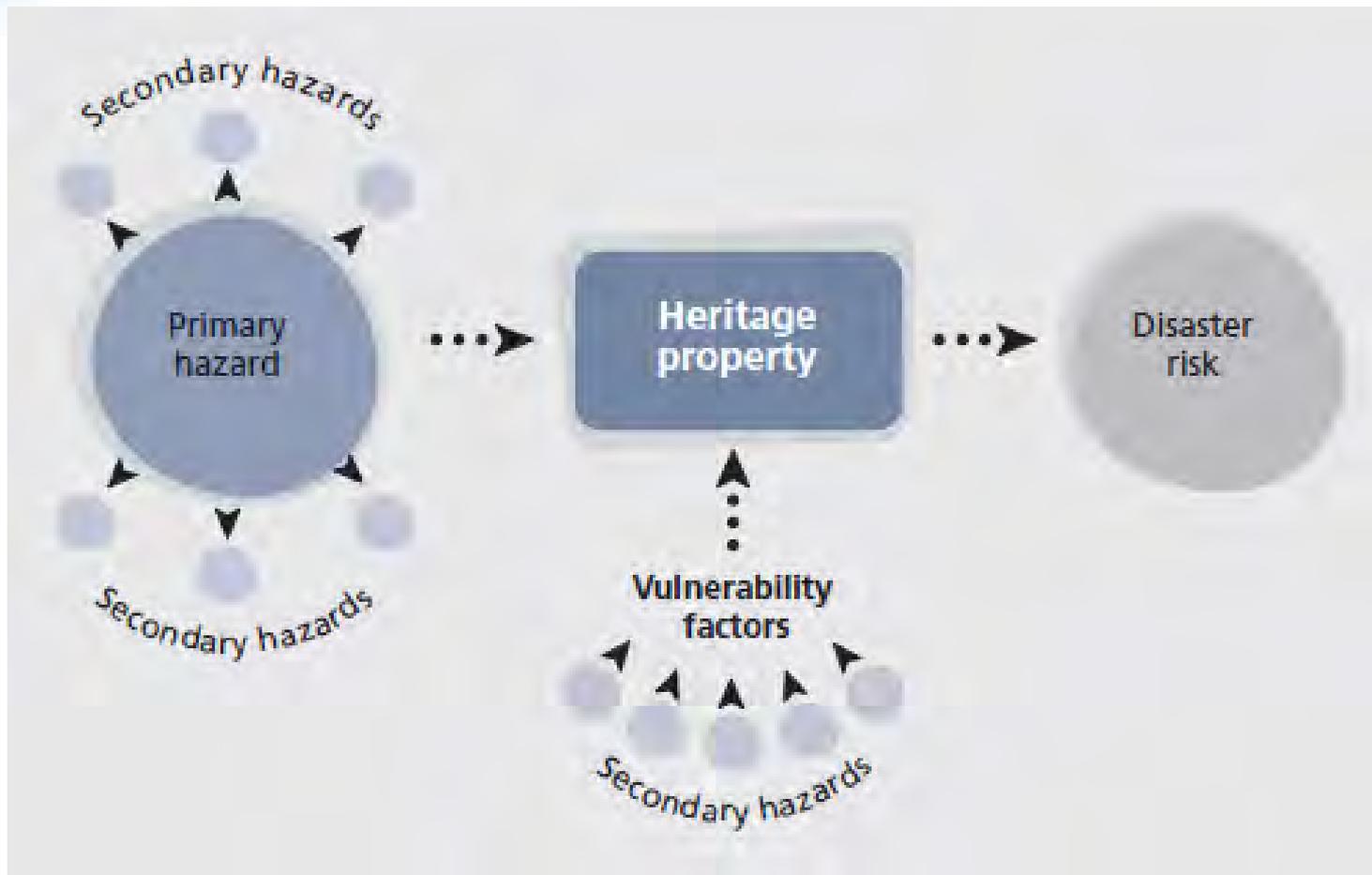
## **Step 3- Analyze 'cause-effect relationships'**

the 'cause-effect' relationships between **various primary hazards** and **underlying risk factors** that increase the property's vulnerability and expose it to disaster risk.

# Analyze the factors that may cause disaster risks to your property



## Step 4- potential impact on heritage values



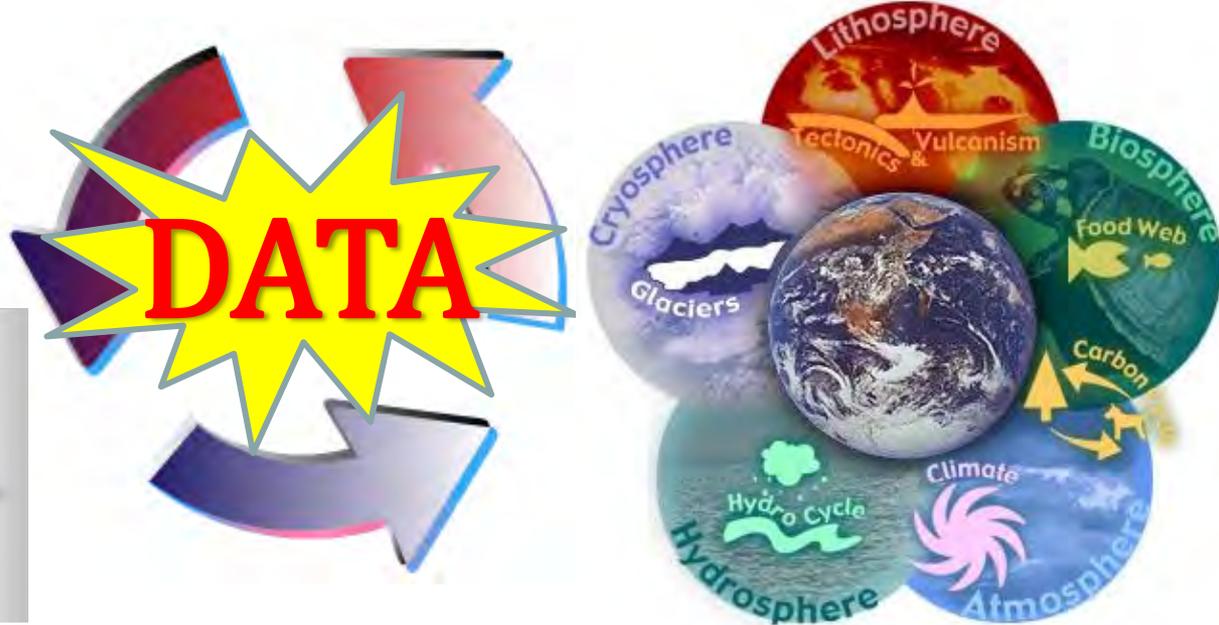
# Earth Observation: A continues vision of our planet



## Earth Observation

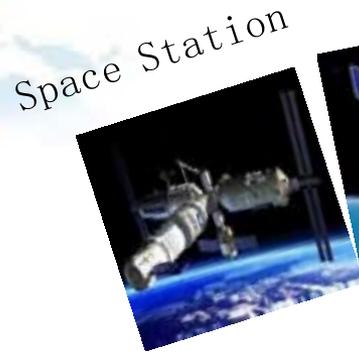


## Earth System

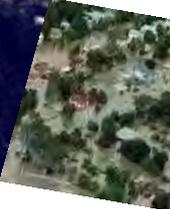


Scientific Research & Human Society

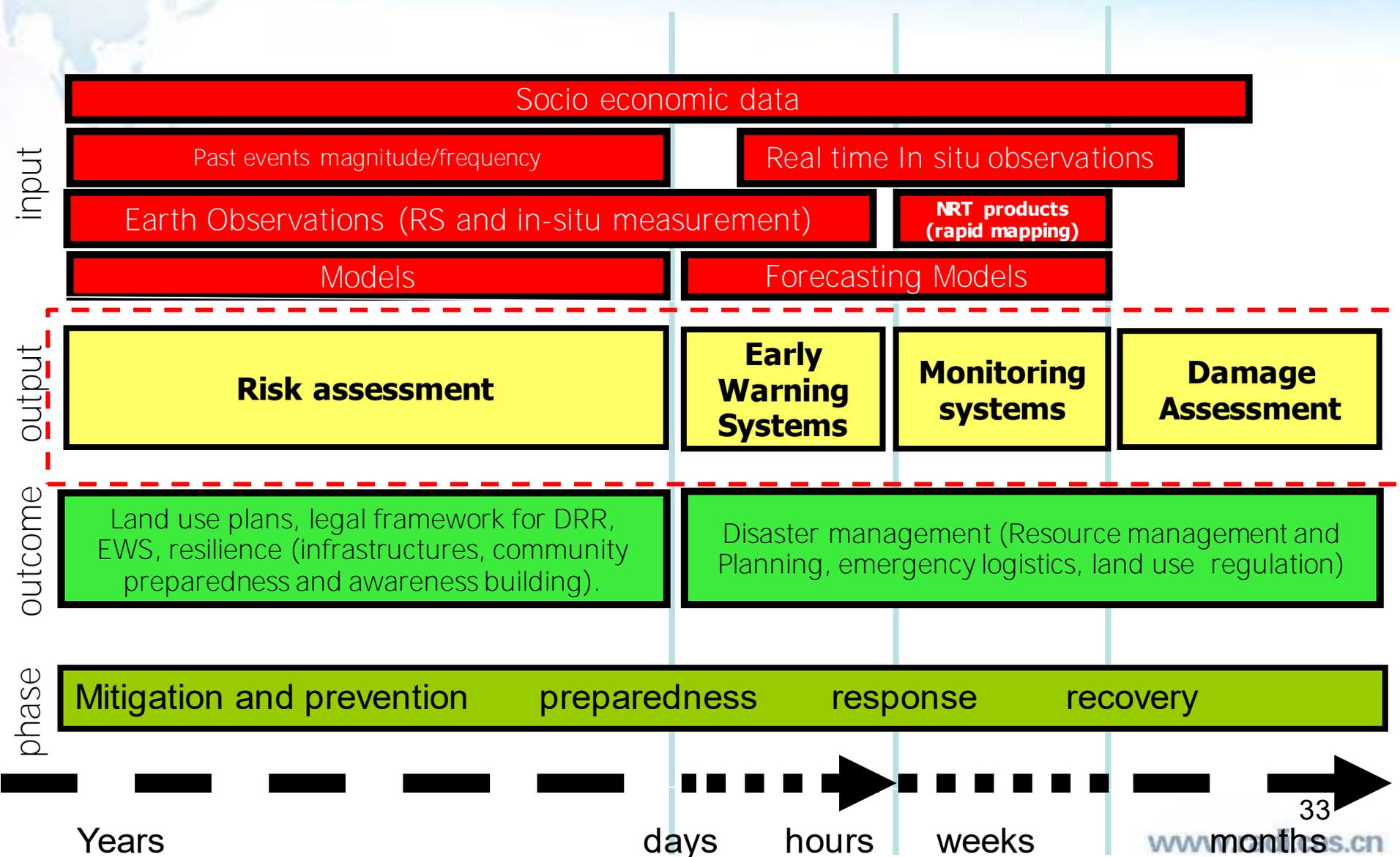
# EO for Disaster Mitigation



Earth Observation Systems



# A (very simplified) logic model for disasters





CNSphoto

**flood**



cnsphoto

# EO for Flood Monitoring- Optical Sensor



## Optical Sensor for Monitoring-SPOT-5

- SPOT 5 was launched on May 4, 2002. They offer a higher resolution of 2.5 to 5 meters in panchromatic mode and 10 meters in multispectral mode.

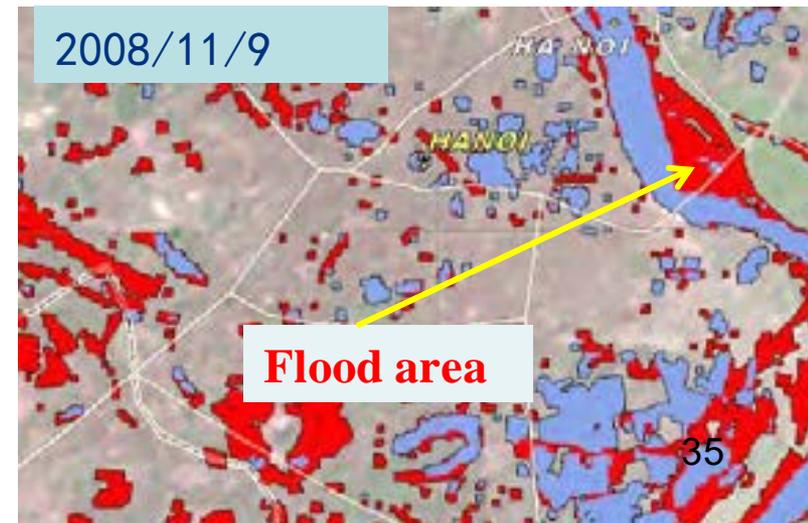


SPOT-5 for Africa floods (ICSMD)

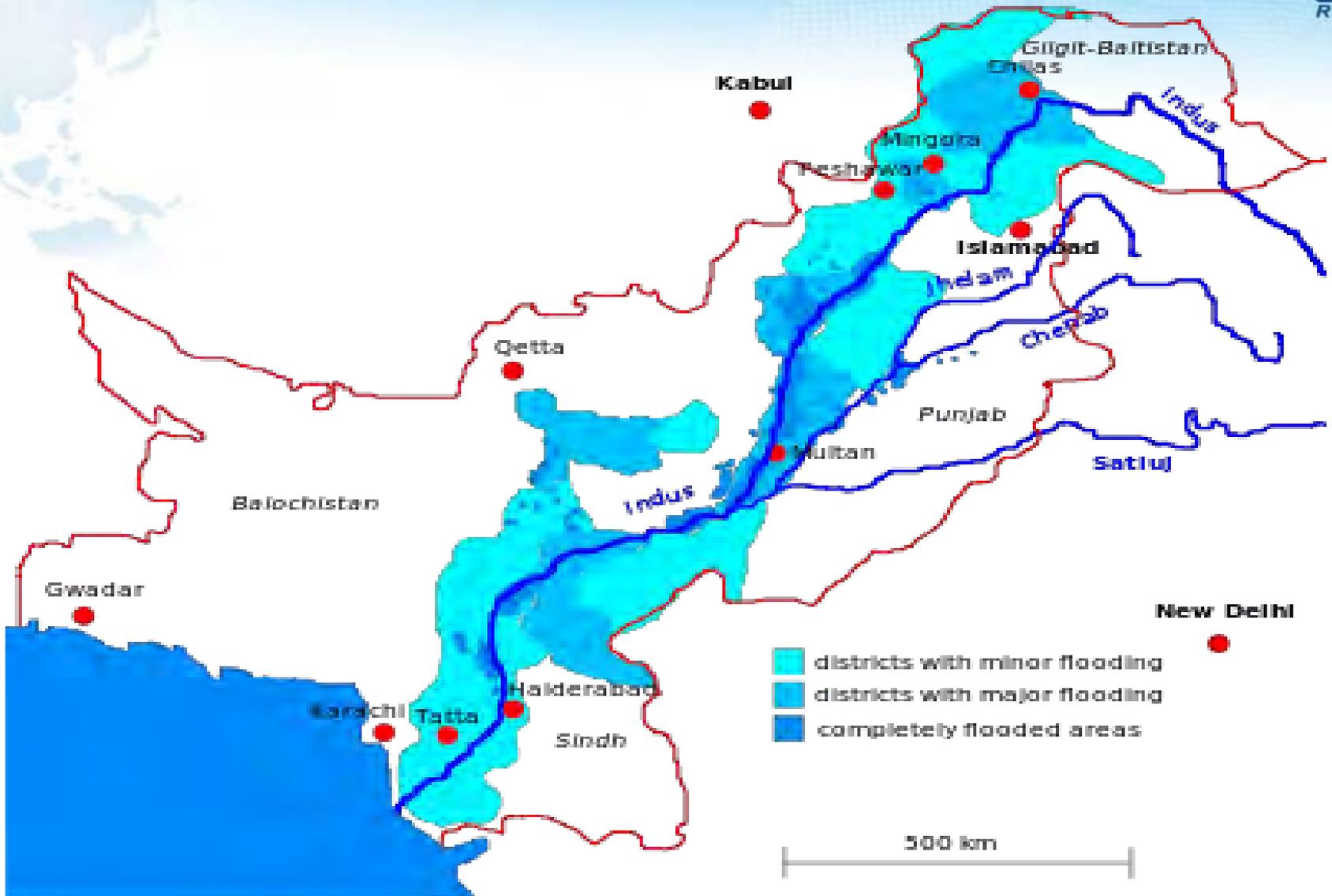
- The Disaster Monitoring Constellation (DMC) consists of a number of remote sensing satellites and operated for the Algerian, Nigerian, Turkish, British and Chinese governments.

## Optical Sensor for Monitoring-DMC

DMC L1R for Vietnam floods (ICSMD)



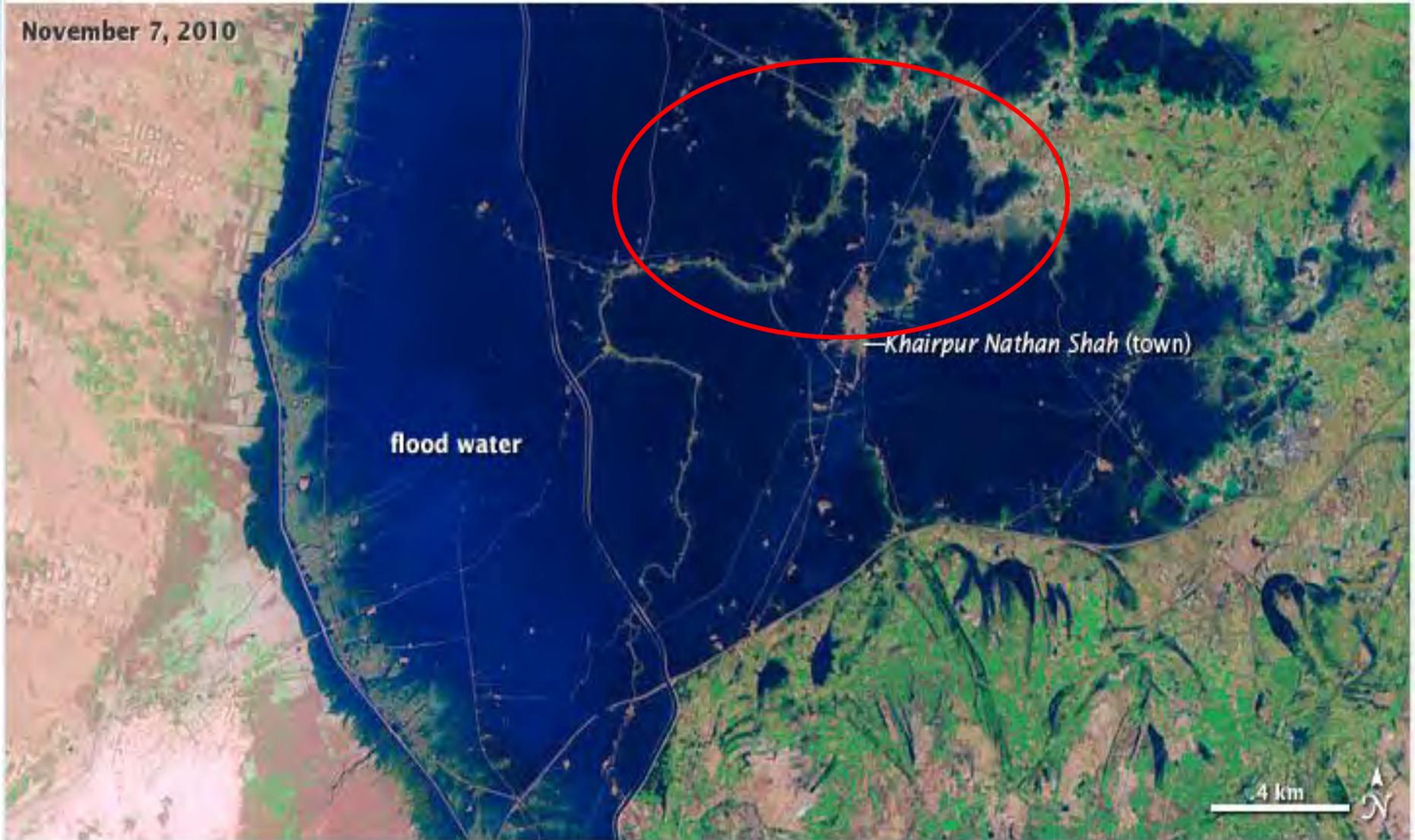
# Flood in 2010 Pakistan



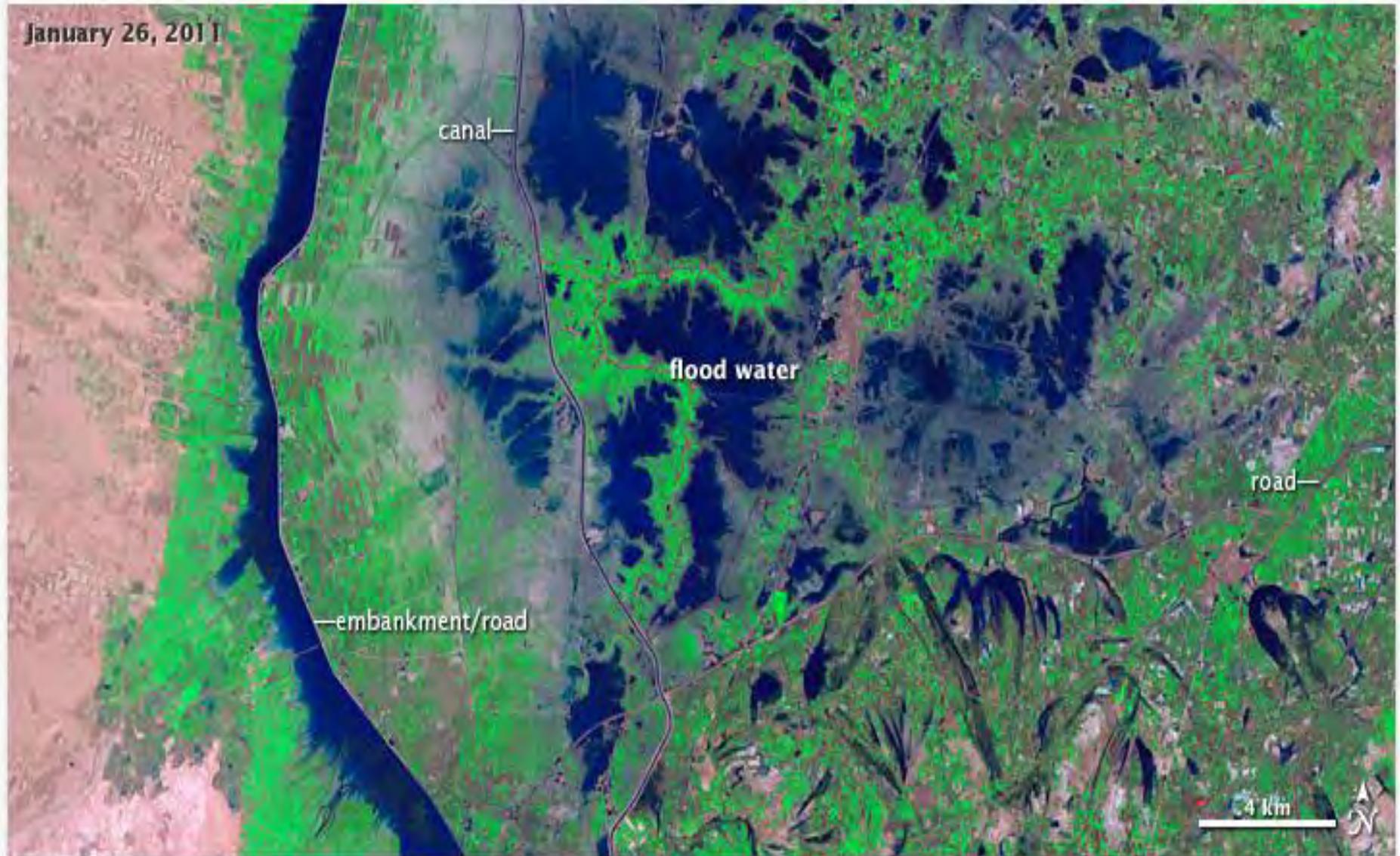
# Flood in 2010 and Emergency response/Daily flood maps



November 7, 2010



January 26, 2011



# EO for Flood Monitoring



## High resolution satellite for floods monitoring



### Worldview -2 (USGS)

WorldView-2 satellite sensor, launched October 8, 2009, provides 0.46m Panchromatic (B&W) mono and stereo satellite image data.



**Maze drought, 2009**



**Rice drought, 2007**



**drought**

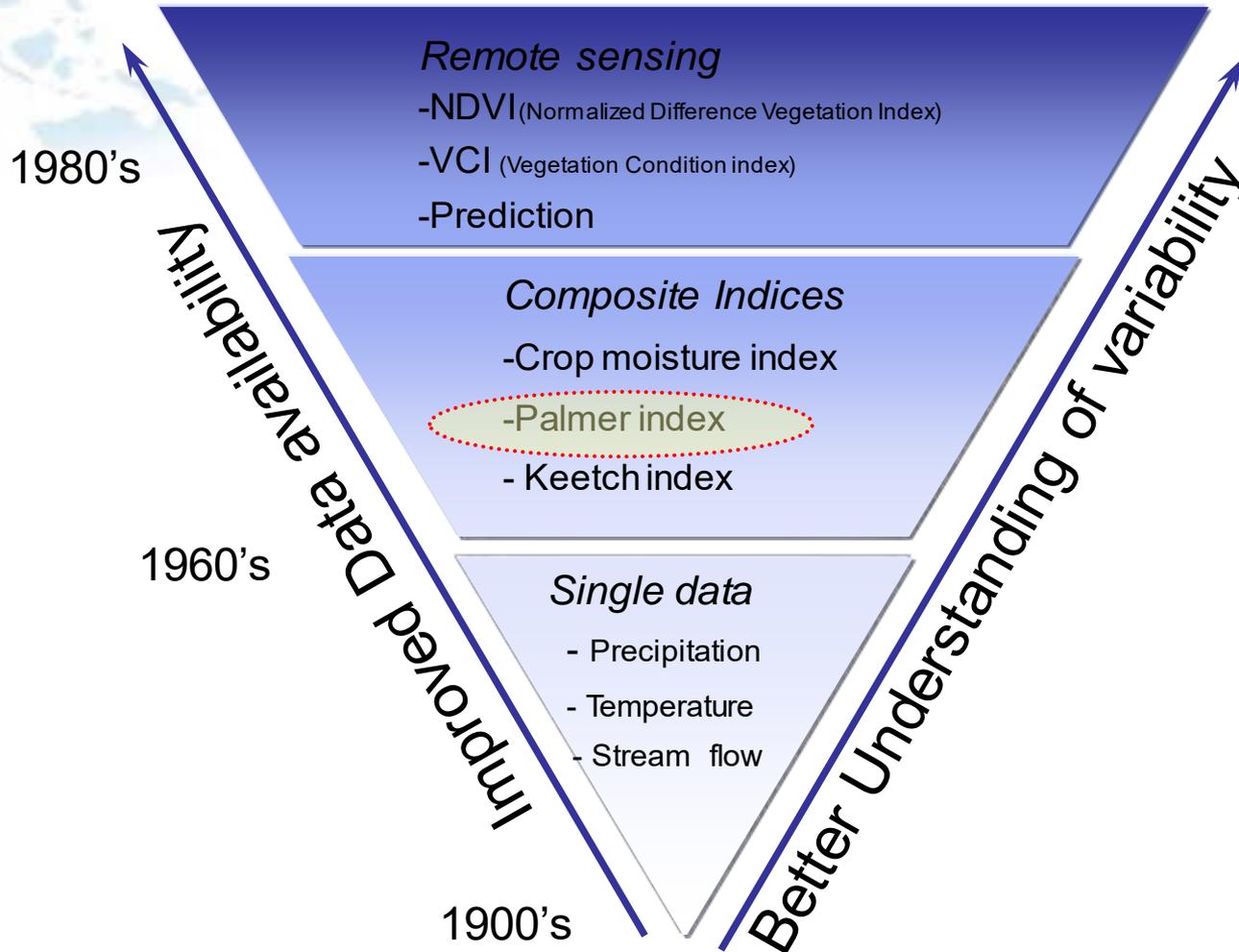
**Wheat freezing and drought**



**Lack of drink water**



# Measuring Drought



# Monitoring drought

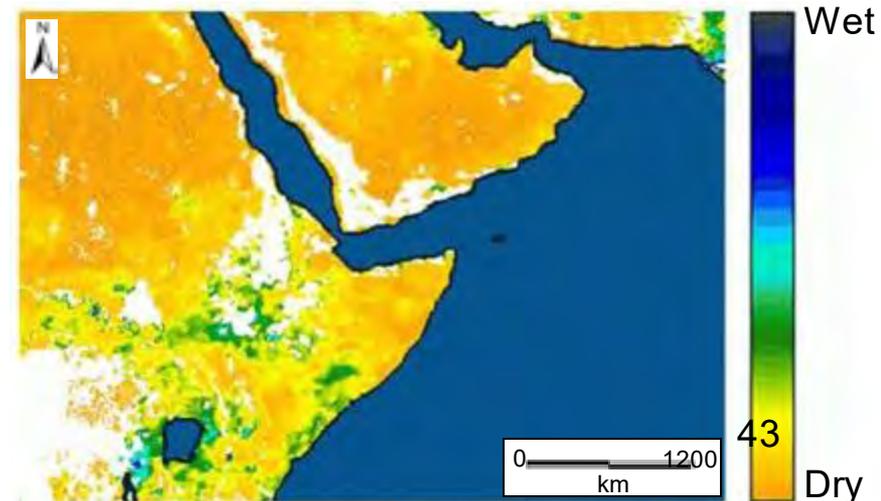


MODIS Vegetation Maps(UN-SPIDER)

MODIS can provide consistent, spatial and temporal comparisons of global vegetation conditions .

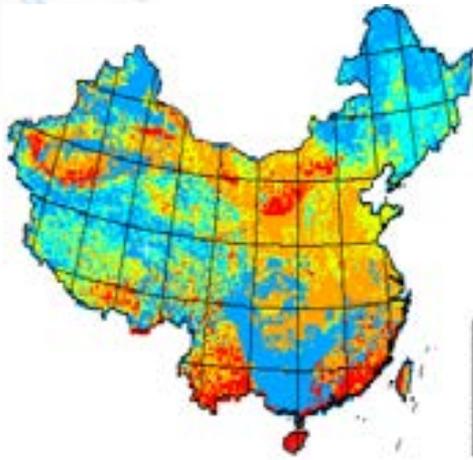
Between July 2011 and mid-2012, a severe drought affected the entire East Africa region. Said to be "**the worst in 60 years**", the drought caused a severe food crisis that threatened the livelihood of **9.5 million people**.

MODIS Drought Index Maps(UN-SPIDER)

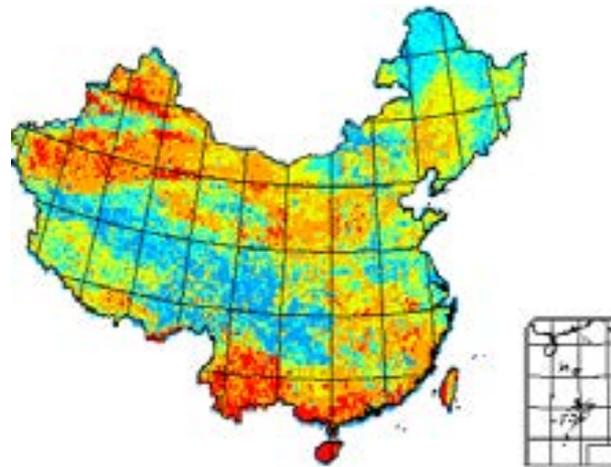


# Monitoring drought

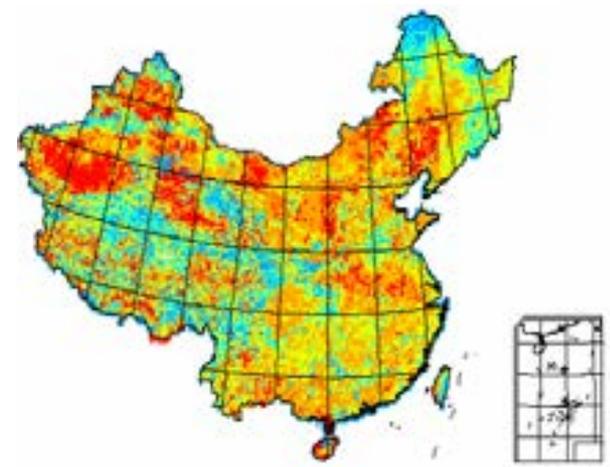
*TVDI*



**first ten days in March**



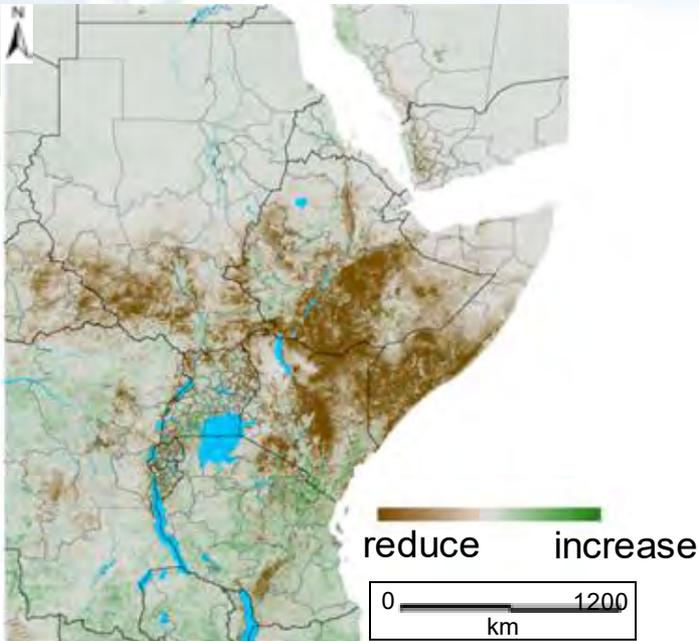
**first ten days in April**



**first ten days in May**



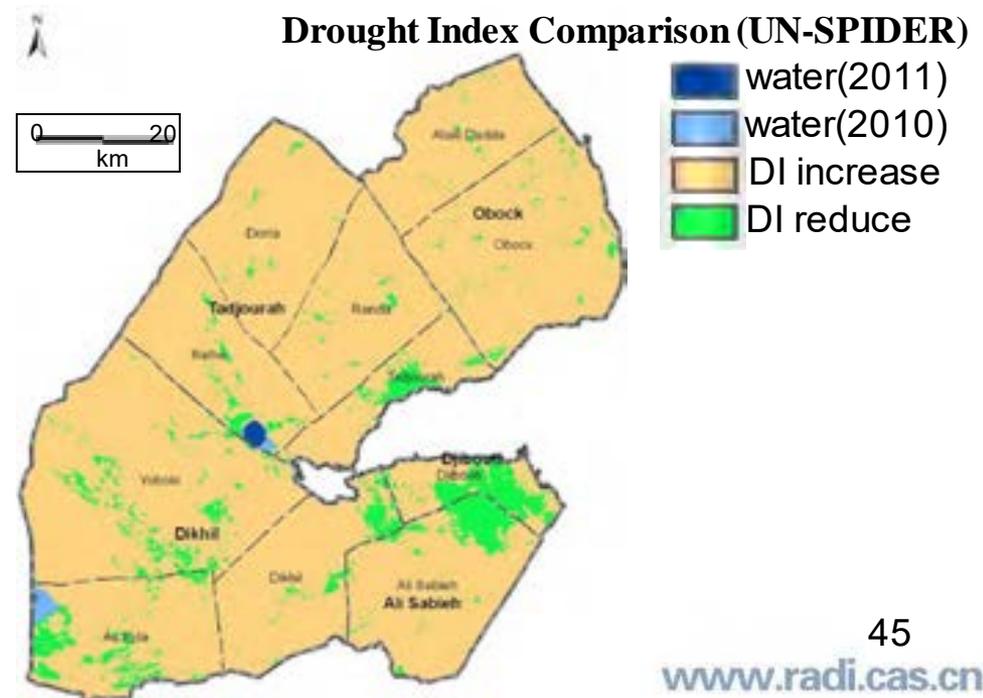
# Monitoring drought



**Vegetation Cover (2011) Vs. Average Vegetation Cover 2001- (USAID)**



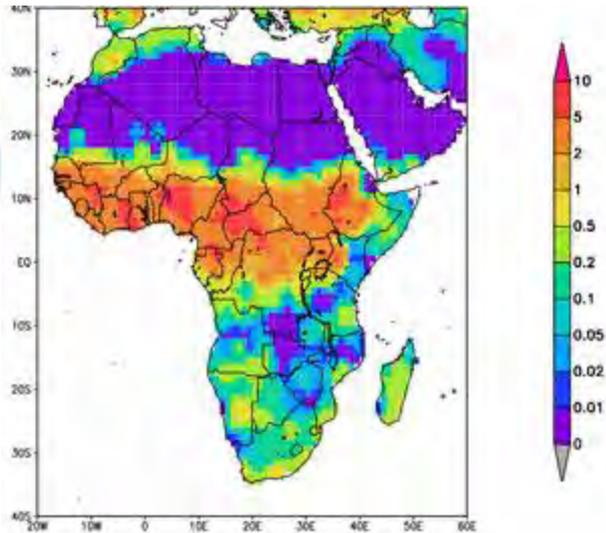
## Temporal Comparison of Drought Impacts through Satellite Data



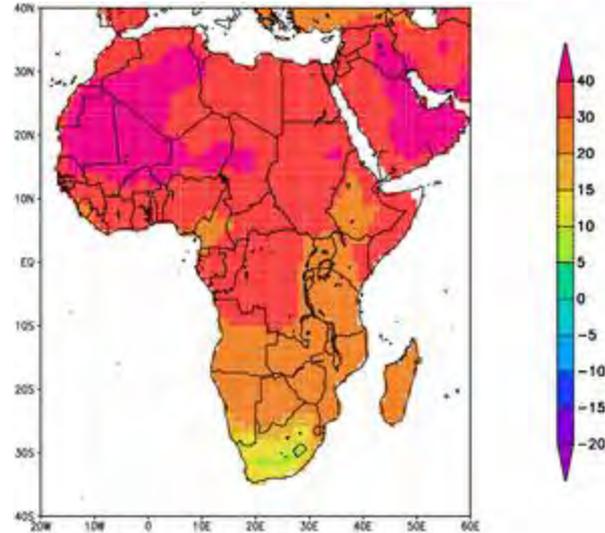
# Drought modeling



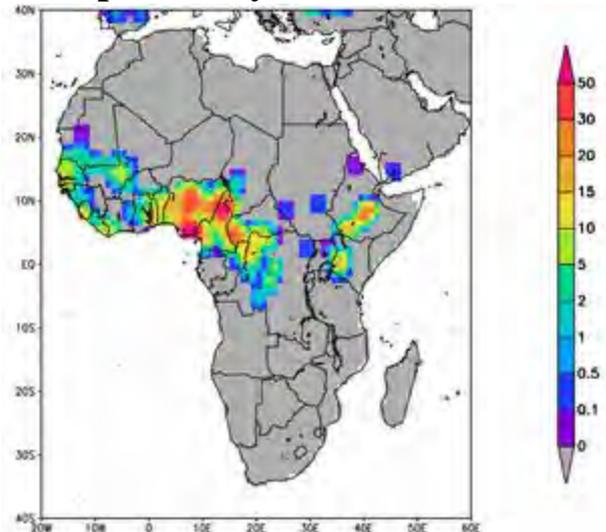
ET(mm/day) 2011/07/02



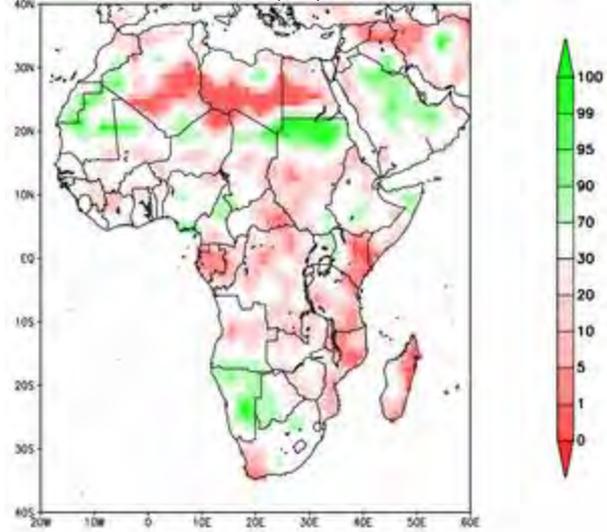
Air Temp. (°C) 2011/07/02



Precp.(mm/day) 2011/07/02



Rate of Soil Mois.(%) 2011/07/02



[http://hydrology.princeton.edu/~justin/research/project\\_global\\_monitor/](http://hydrology.princeton.edu/~justin/research/project_global_monitor/)

# Earthquake



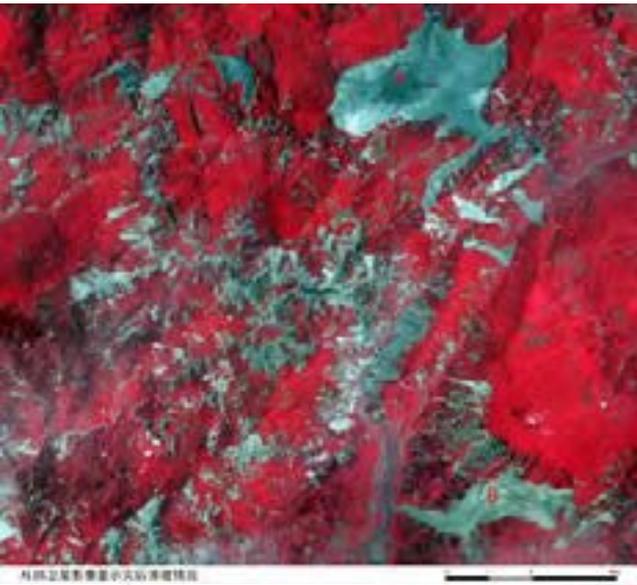
# Wenchuan Earthquake

- Time: 12/05/2008 12:28PM;
- Magnitude: Ms.8.0;
- Location of epicenter: 103.4°E, 31 ° N;
- Geographic Location: Wenchuan,Beichuan,Sichuan province, China;
- Depth of Seismic focus: 14KM;
- Epicentral Intensity: 11Degree;
- Casualty: Death 69142, Missing 17551.



# geology disaster after earthquake

image in Xiao Maoping Wenchuan County in 5.15



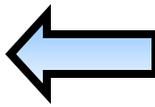
汶川地震震害小茅坪村滑坡情况



汶川县小茅坪村机载光学遥感图像

0 50 100 200m

2008年5月15日拍摄。图像由四川省地震局提供。在地震的强烈作用下，地形发生剧烈变化，导致滑坡、泥石流等地质灾害。



Geology disaster in Chenjiaba Beichuan  
50% surface has been destroyed , such as  
landslides and collapse form after-quake- lakes.



# Road and facility monitoring



Jinhe phosphorite mine in Hongbai county



# Road and facility monitoring



- A: 秦堰楼
- B: 二王庙
- C: 安澜索桥
- D: 飞沙堰
- E: 宝瓶口
- F: 伏龙观



Ancient architecture damaged in Du Jiangyan



Du Jiangyan key water control project is good after earthquake



# Zoology damage monitoring



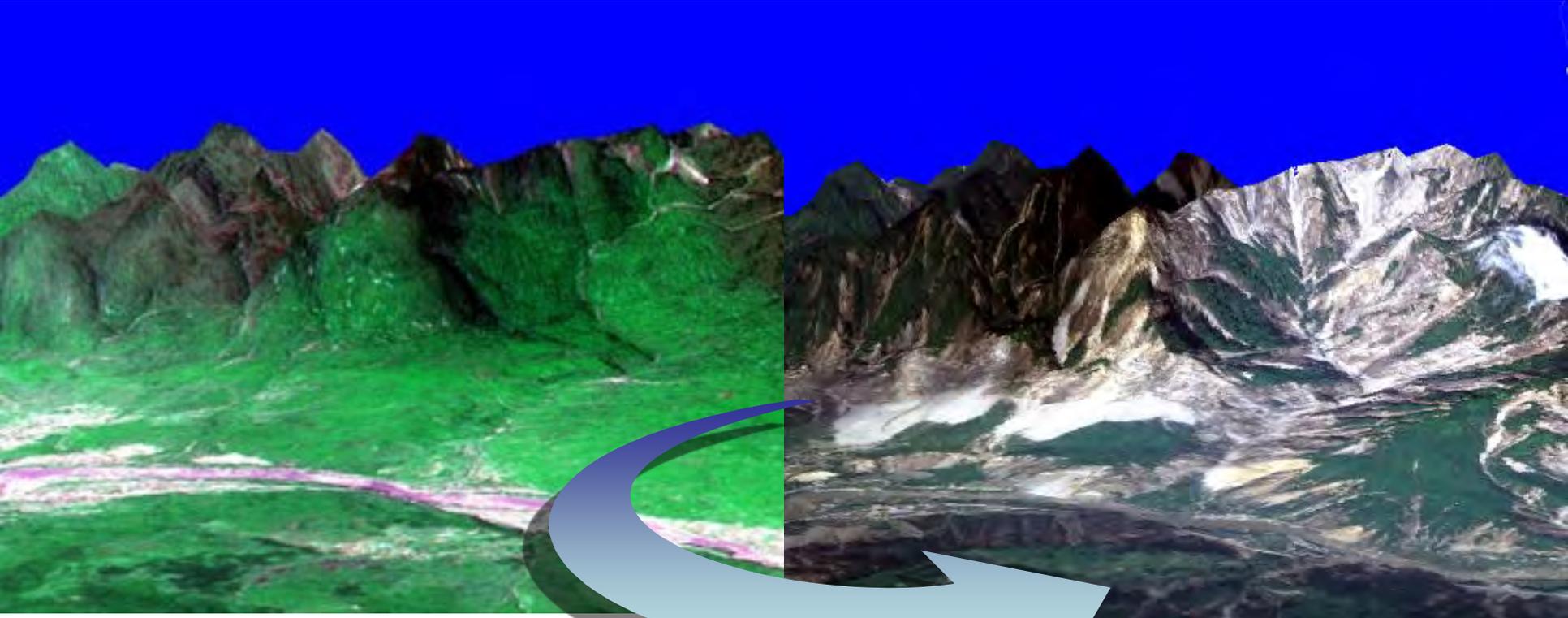
Long Chigang before earthquake



Long Chigang after earthquake



# Zoology damage monitoring



**Landscape  
before in Yinxing  
2007-5-9**

**Landscape  
after in Yinxing**  
  
[www.radi.cas.cn](http://www.radi.cas.cn)  
**2007-5-16**

# Thanks!



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