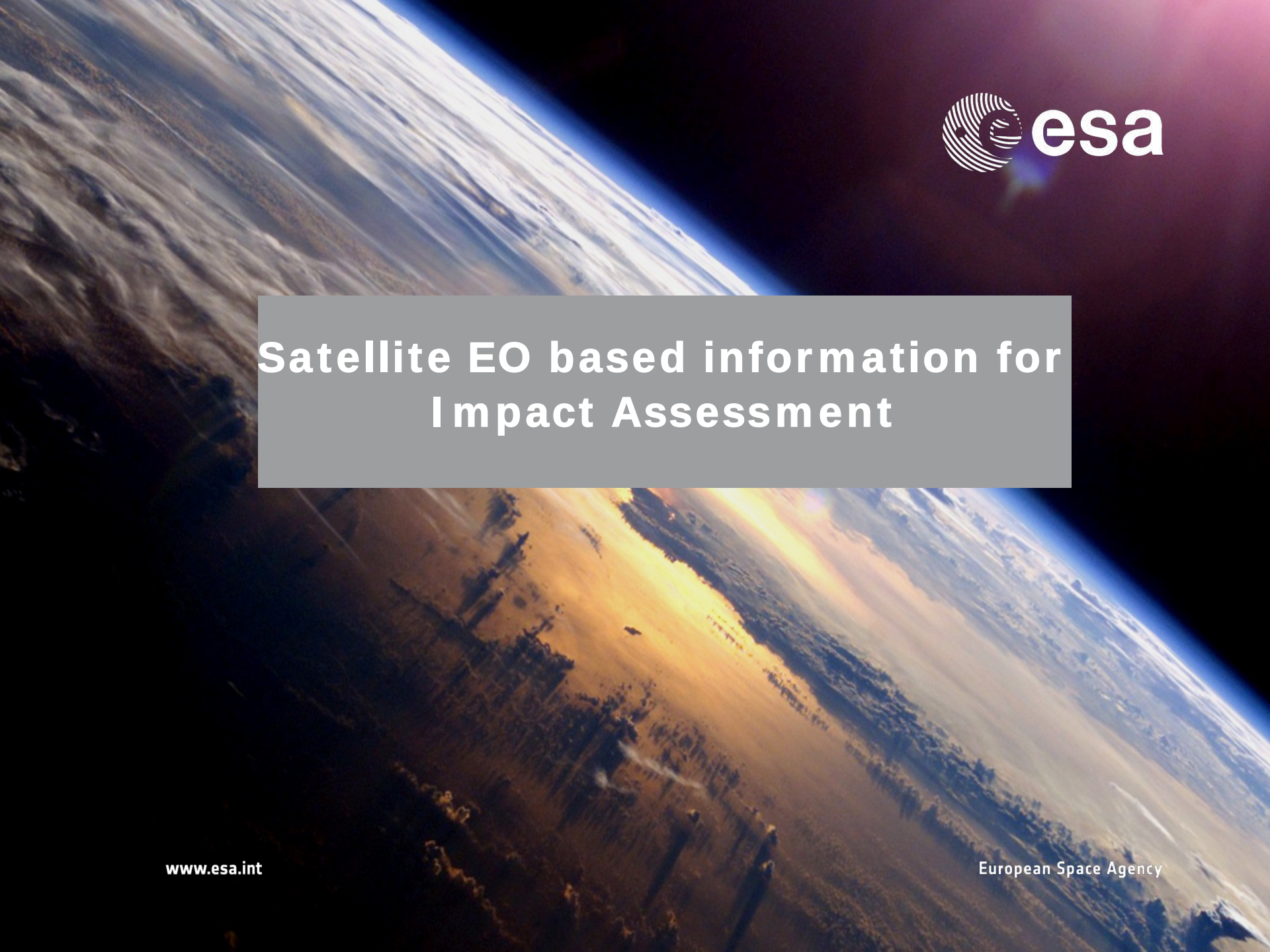


Satellite EO based information for Impact Assessment

Some Abstract Considerations

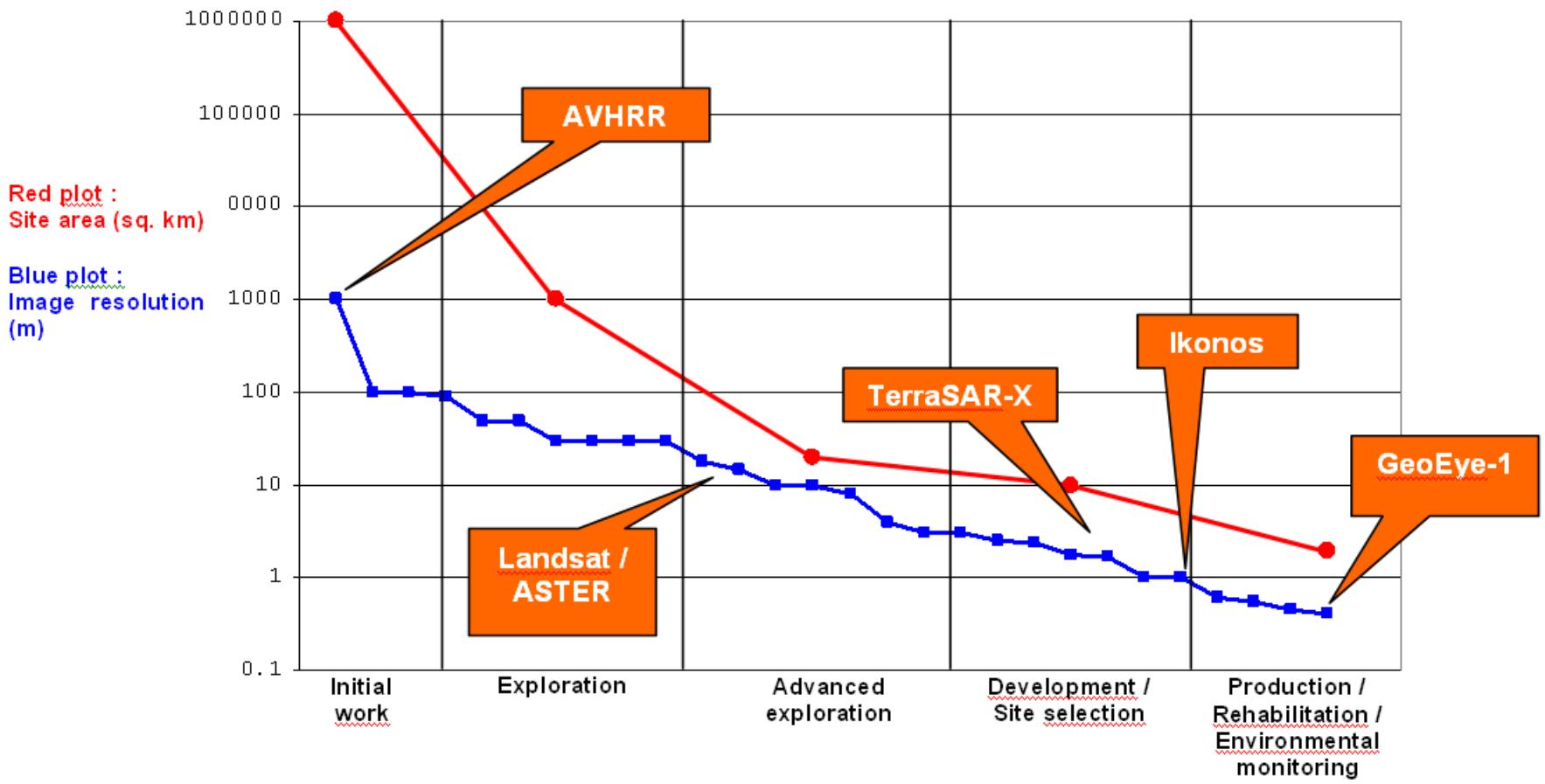
Possible contributions to Impact Assessment

1. Construction of reference baseline from historical data
2. Monitoring impact of on-going projects
   - Environmental impact – eg pollution/contamination, habitat degradatation, fragmentation, change in exposure to natural disasters (eg flood, landslide)
   - Social impact (eg displacement of locals, fragmentation of crop land, access to water etc)
3. Monitoring overall impact of an investment project:
   - Map changes in relevant conditions over a set of reference years to detect and assess consequences of interest (eg change in crop cover, reduction in forest conversion,
4. Characterisation of impact on one-off events
5. Conducting regular required EIAs
6. Remediation compliance (ie ensuring overall net lack of impact)

Issues to consider

1. What are the indicators of interest to the stakeholders and is there a related spatial signature as a component of these indicators?
2. Are there measureable changes that enable construction of these indicators (case in point – consider where avoided deforestation is an indicator of interest). Do the measurable changes actually correspond to variations in the indicator being generated?
3. Are the changes detected actually related to the project being monitored (ie how to characterise the spatial and temporal footprint of the project being monitored)?
4. Spatial and temporal scales
5. Is there a certified process for assessing the impact of interest and is this defined in such a way that EO derived information can/cannot be used?

Mining activities – spatial scales and EO obsering resolutions



Critical enabling capabilities

- Long term archive of image data:
  - Radar imagery 1991 – present
  - Optical imagery 1988 – present
- Interoperable data - Extraction of information independent of exact sensor acquiring imagery
- Independent validation:
  - Information extraction based on peer reviewed algorithms
  - Application of algorithms is structured as series of standard processing steps
  - Implementation performance is verified over appropriate number and types of test site under representative environmental conditions
  - Implementation approach is reproducible by independent third parties
- Acceptance as evidence

Reference Baseline

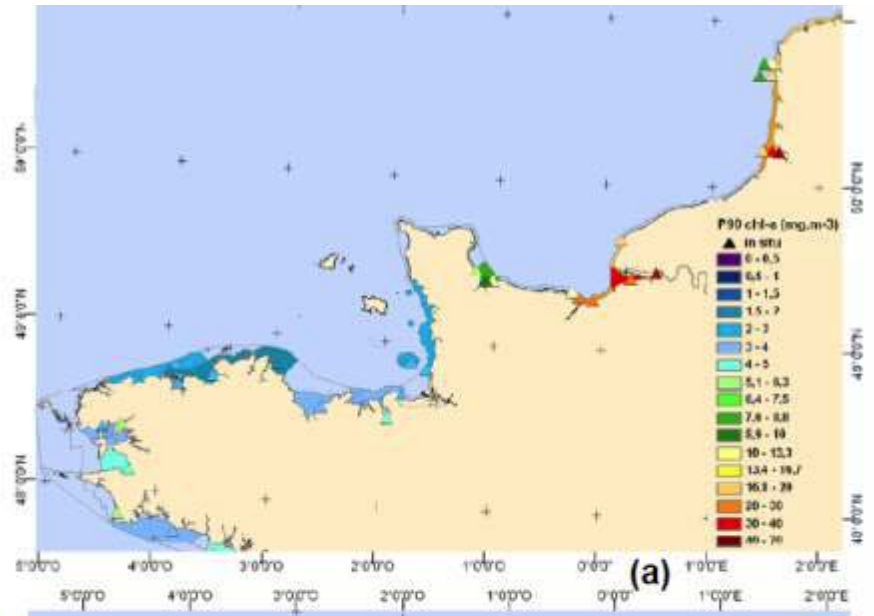
Considerations for baseline construction

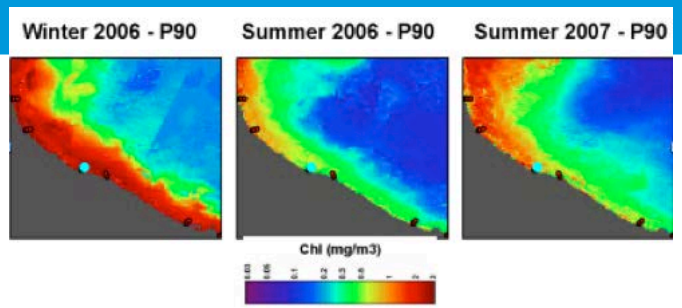
- Two situations with different implications:
    1. Activity has already started
    2. Activity is still to be initiated
- For situation 1:
    - Agree reference epoch
    - Agree parameters which effectively characterise the baseline situation
    - Review availability of archived imagery/data
    - Construct reference maps (eg forest cover)/statistics/climatology (eg seasonal chlorophyll-a concentration, monthly PM10 concentration)
- For situation 2:
    - Agree area of interest and parameters which effectively characterise the baseline situation
    - Work with satellite operators to acquire all appropriate imagery data for area of interest
    - Construct reference maps

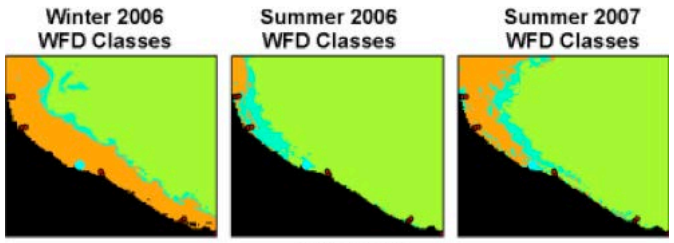
Illustrative examples

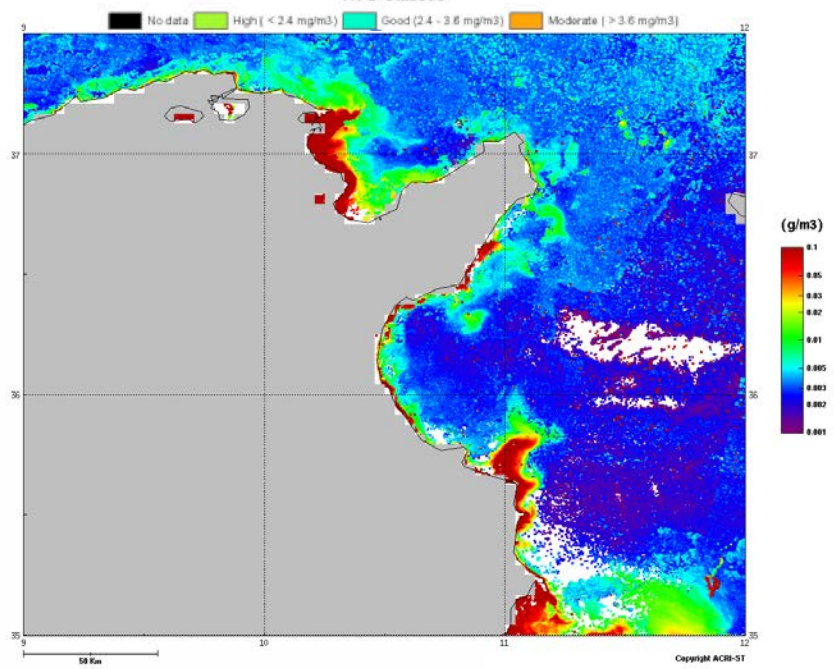
- Static information:
  - National forest cover for reference year (eg for REDD)
  - Agricultural practices prior to investment in improved irrigation
  - Forest habitat status prior to initiating mining operations
  - Coastal habitat status prior to construction of new terminal/ deployment of new aids to navigation (eg Marine Highway)
  - Distribution of houses prior to a development activity (eg dam construction, mining activity, road/rail construction)
  - Area covered by informal housing
- Process characterization
  - Coastal conditions during baseline period (eg for EU Water Framework Directive, Marine Strategy Framework Directive)
  - Statistics of occurrences of oil discharges from vessels prior to starting operational surveillance
  - Rate of change of coastline prior to remediation measures
  - Land deformation rate due to ground water extraction
- Exposure to natural disasters (eg flood, landslide)

Baseline coastal water quality









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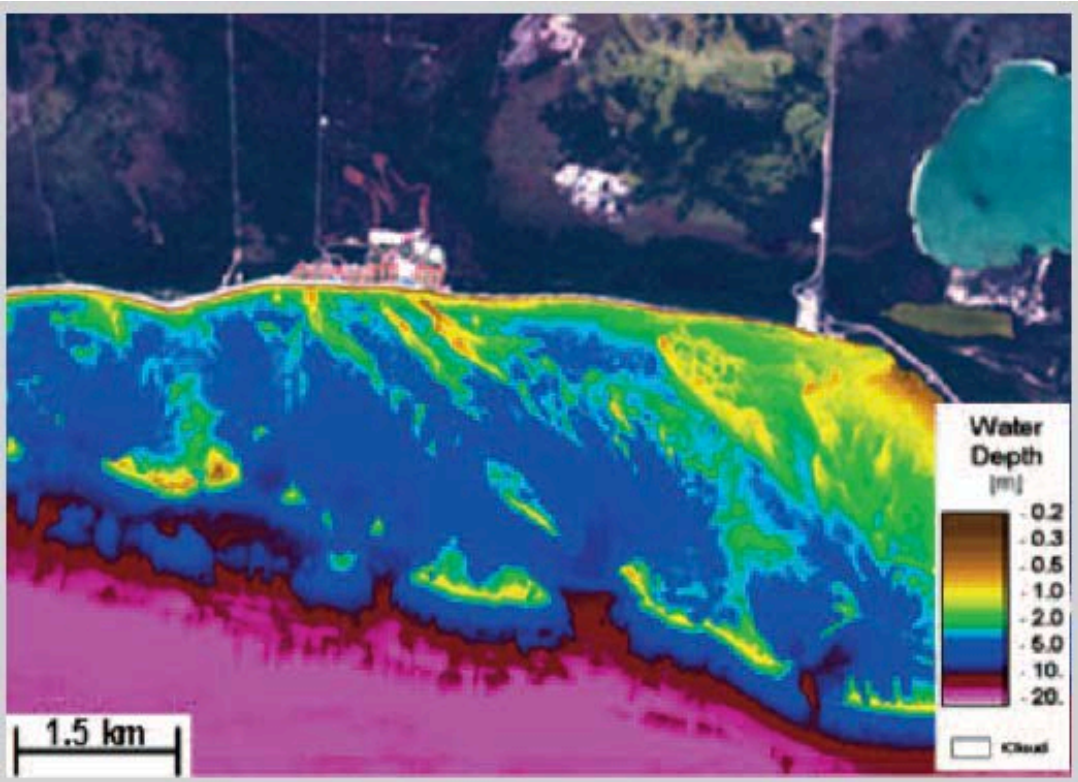
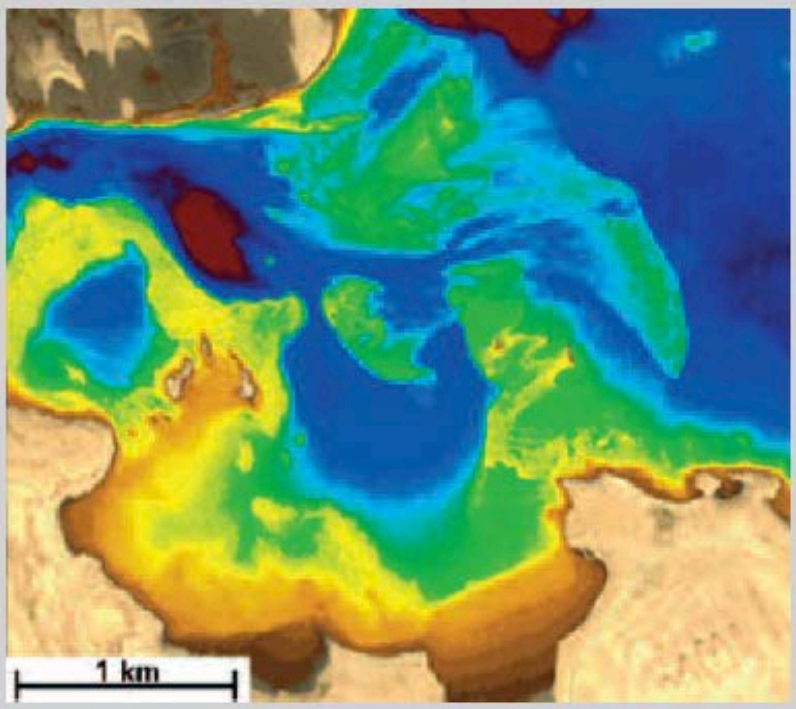
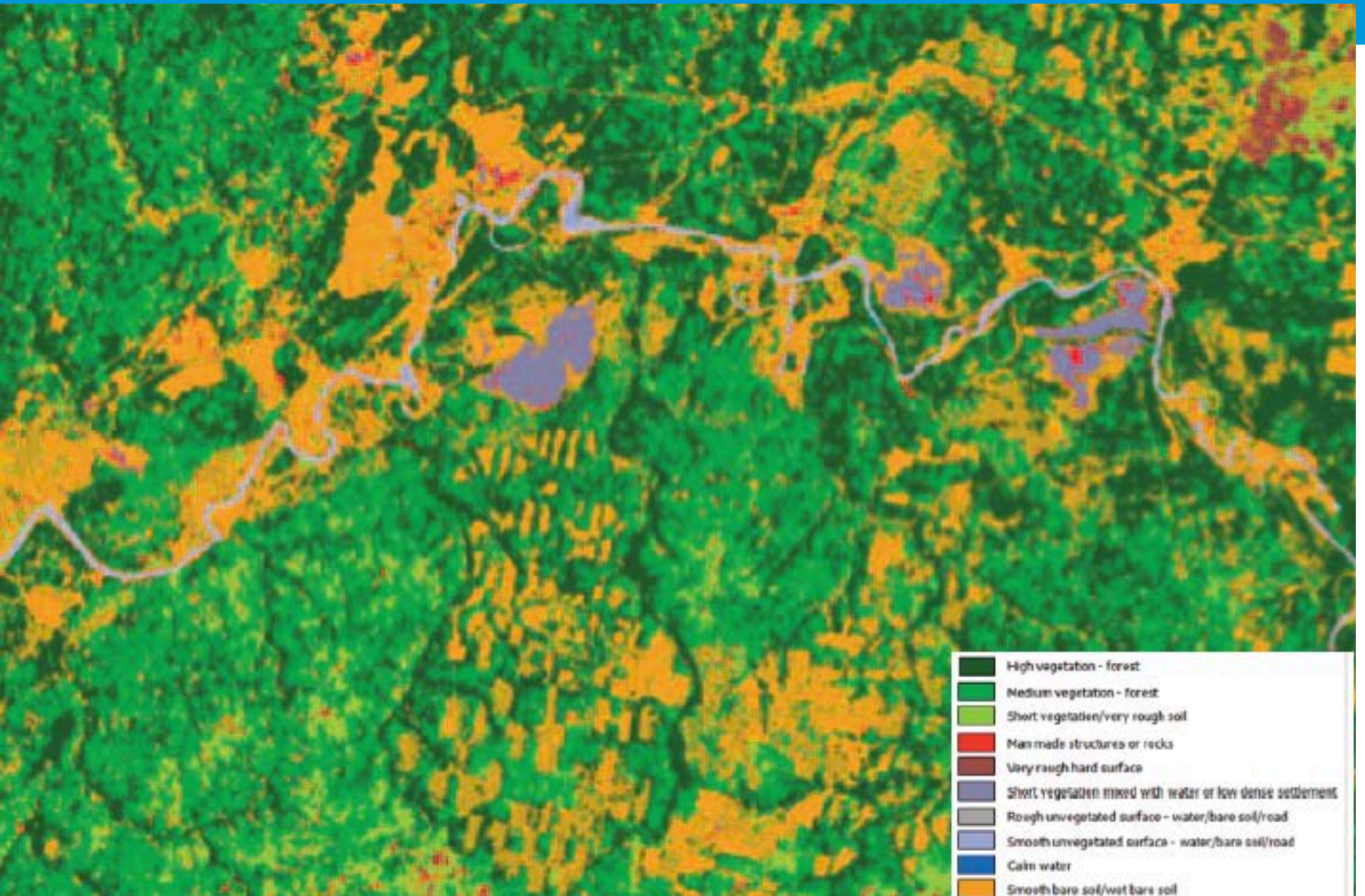
Baseline coastal habitat distribution

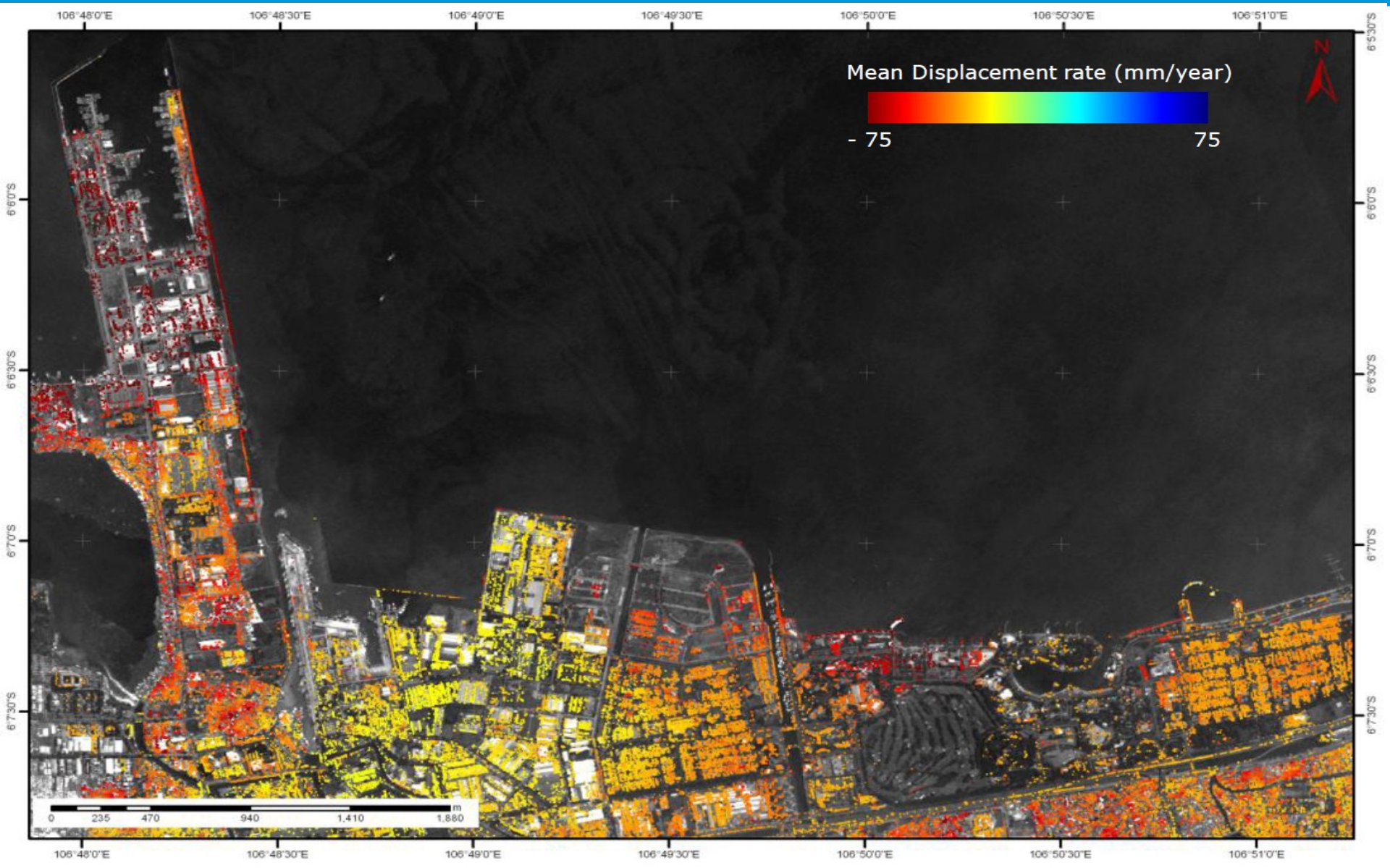




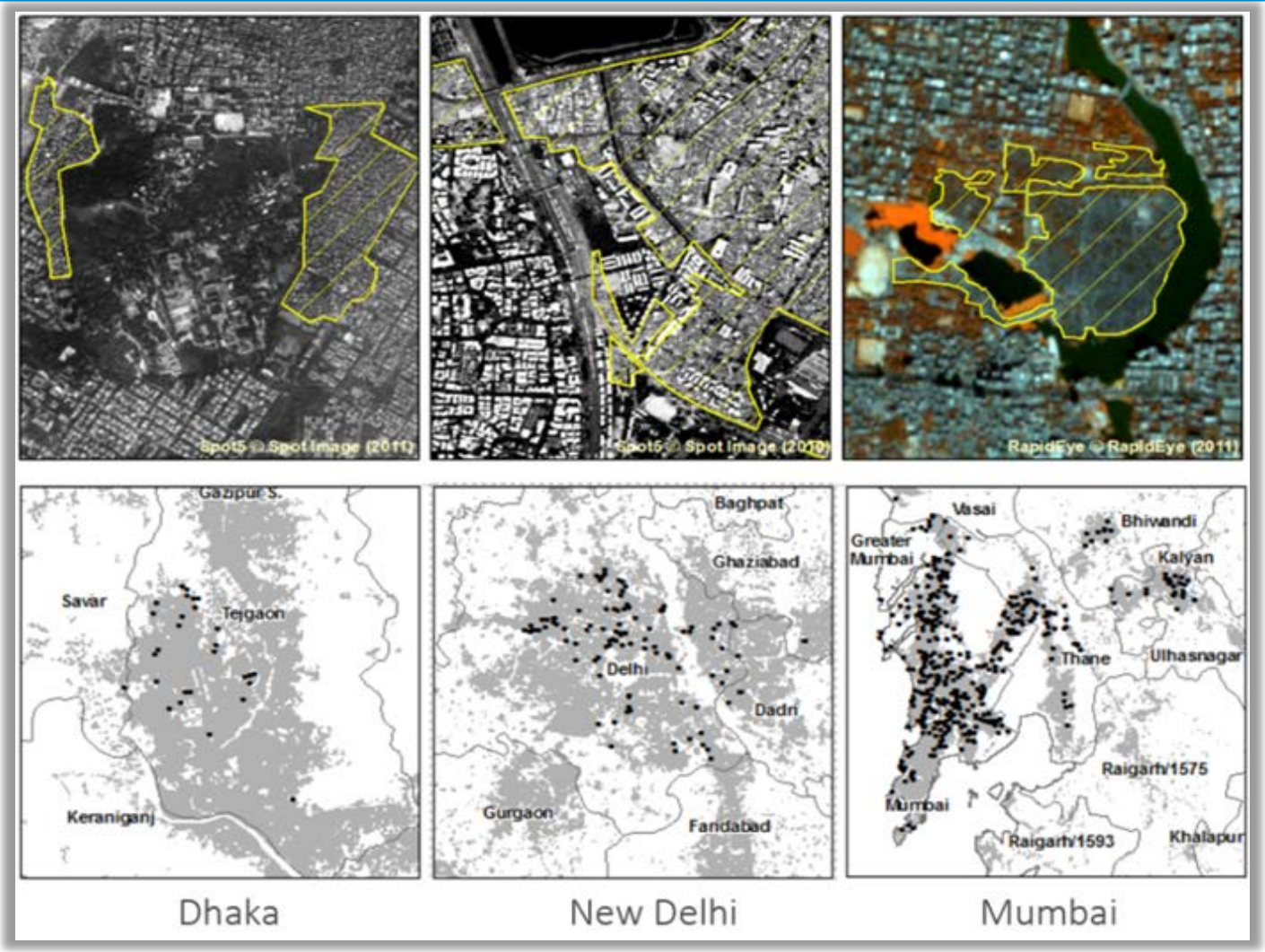
Baseline forest status



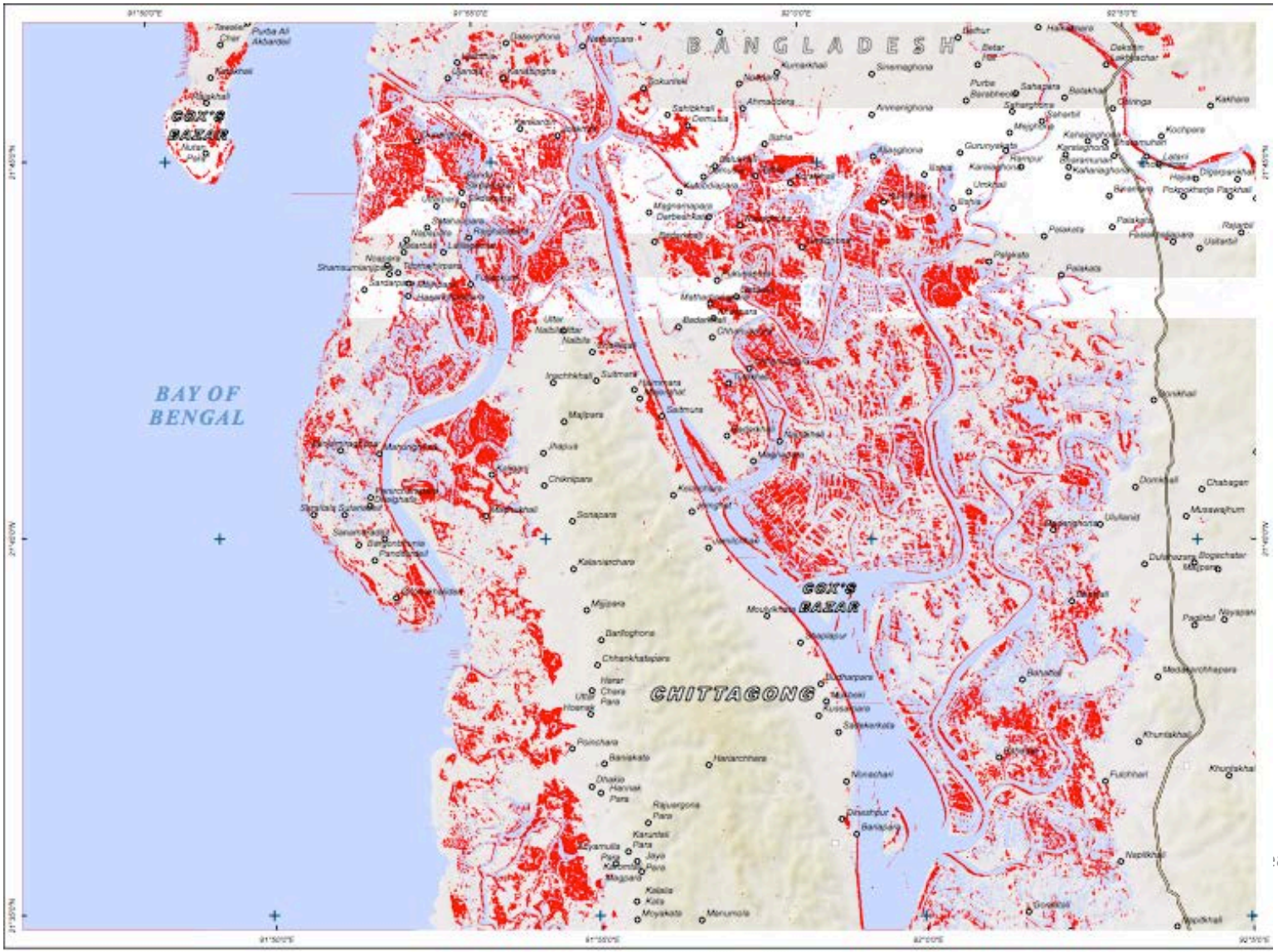
Baseline subsidence rates



Baseline urban mapping



Baseline flood risk



Monitoring impact of on-going projects

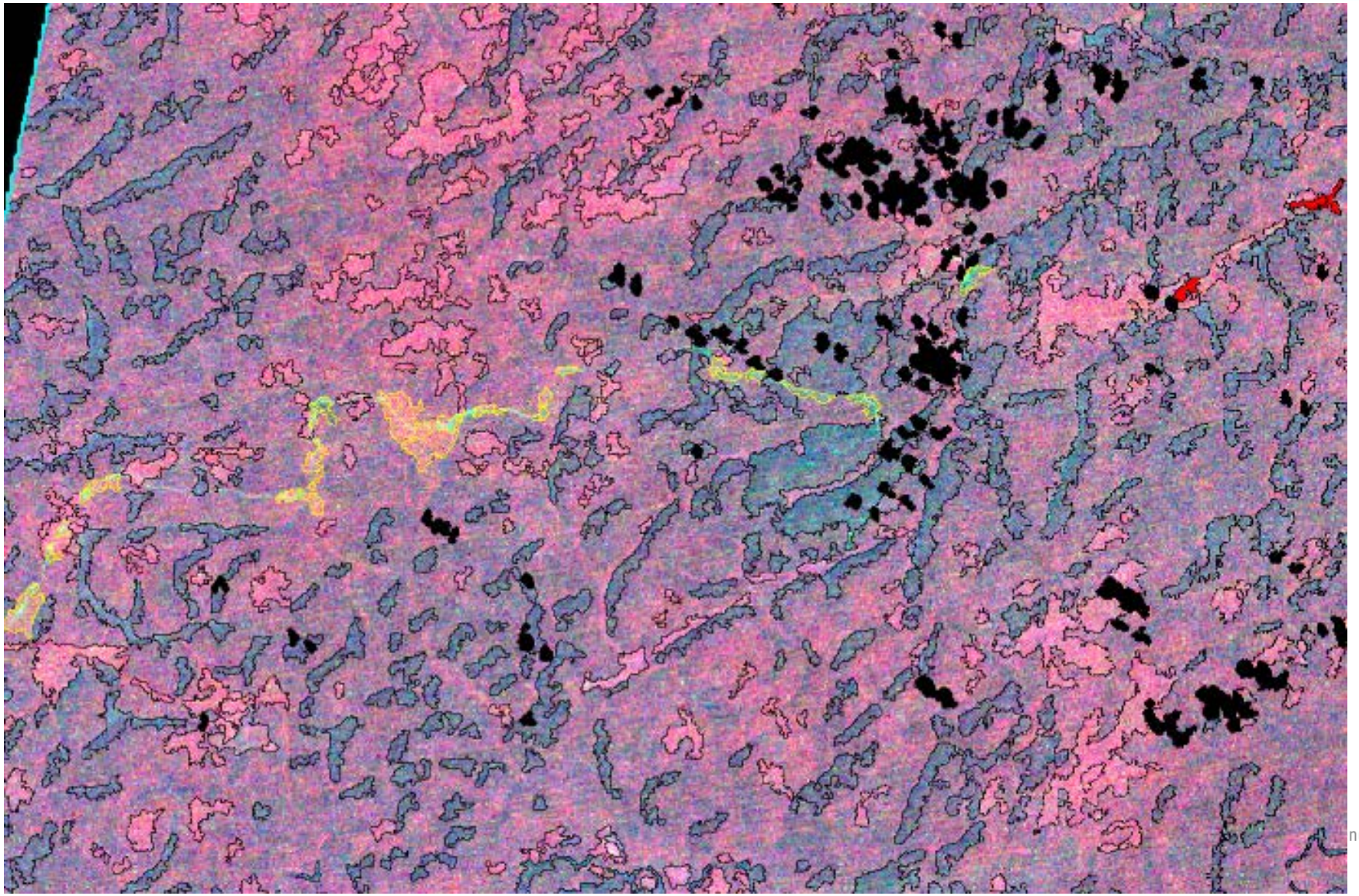
Typical monitoring situations

1. Detection of changes caused by project execution
    - Habitat degradation/fragmentation
    - Surface water contamination
    - Changes in surface water distribution
    - Changes in housing distribution
    - Changes in land use practices
    - On-set of land subsidence
2. Impact assessment approach:
    - Dedicated data acquisition strategy matched to estimated:
        - time-scale of change
        - spatial-scale of change
        - spatial extent of change
    - Analyse changes as project progresses
    - Communicate findings with project implementation team to review monitoring approach and ensure project impacts are minimised as the project progresses

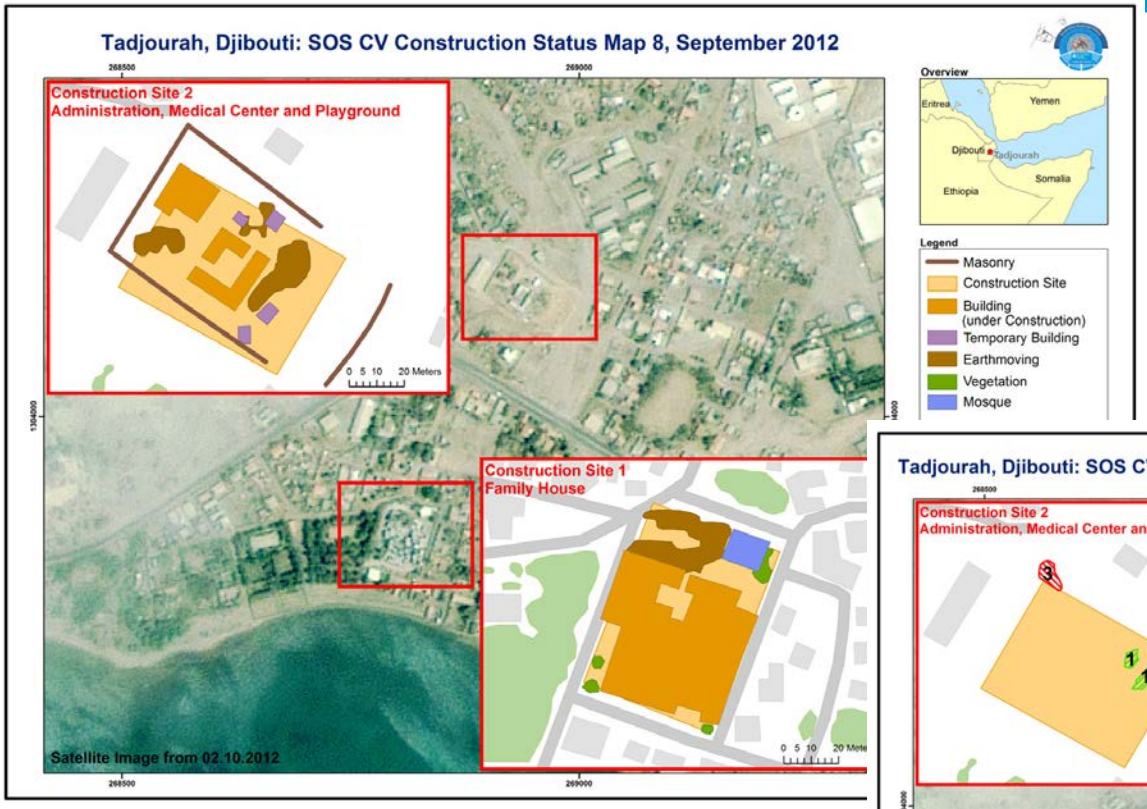
Illustrative examples

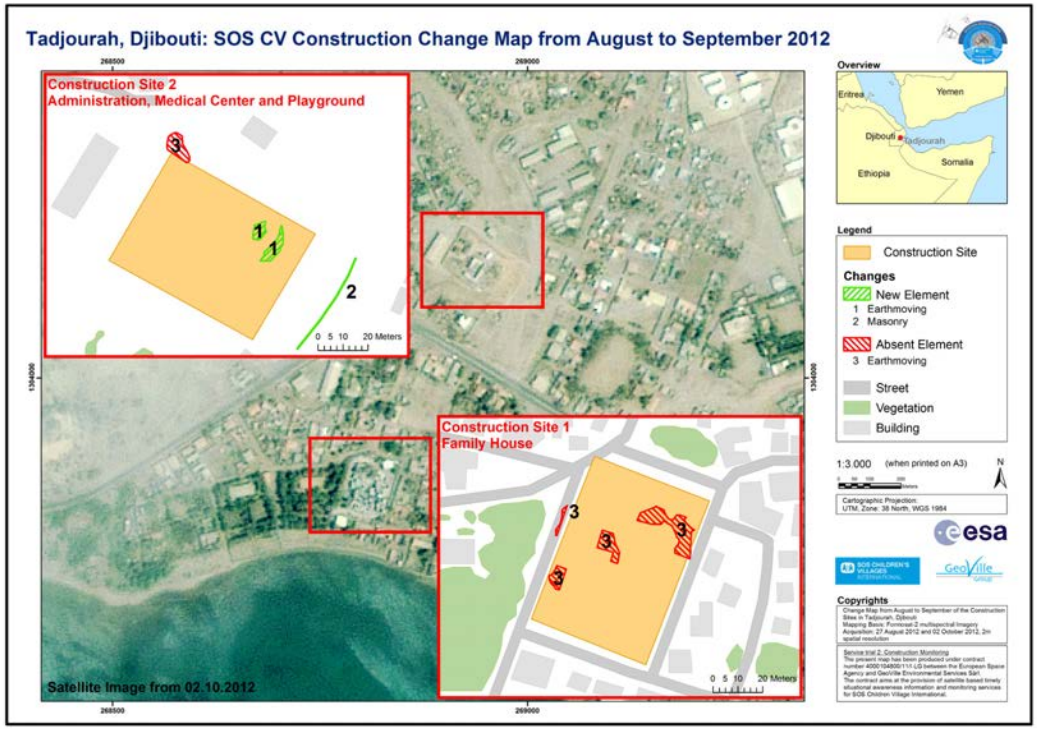
1. Impact of construction for SOS Children's Villages
2. Environmental impact of motorway construction
3. Environmental impact of oil sands processing on surrounding habitats
4. Detection of land subsidence caused by tunneling of metro lines (eg London, Barcelona)
5. Monitoring pollution occurrence for offshore oil and gas production concessions

Impact of policies

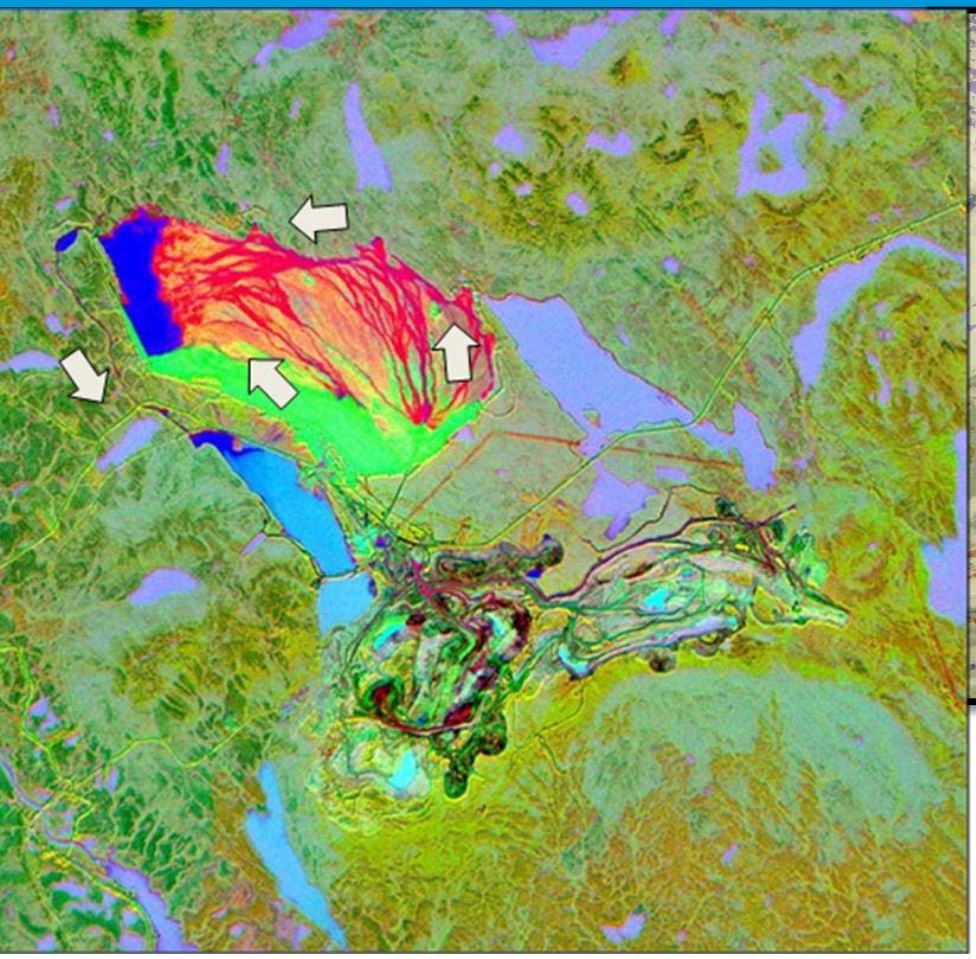


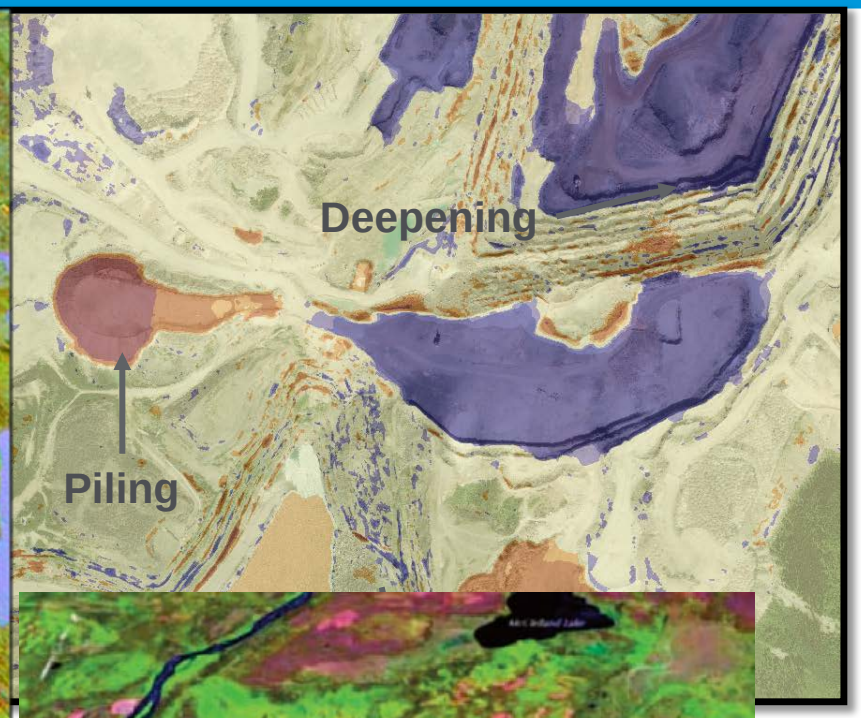
Monitoring construction activities

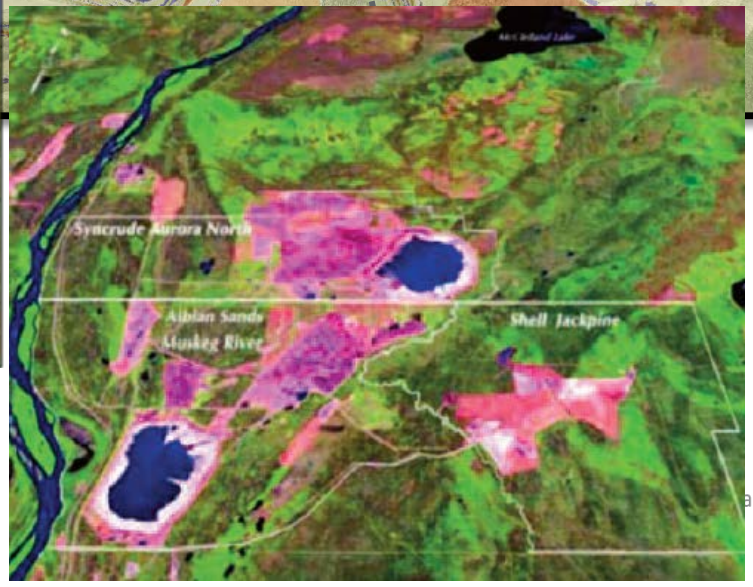




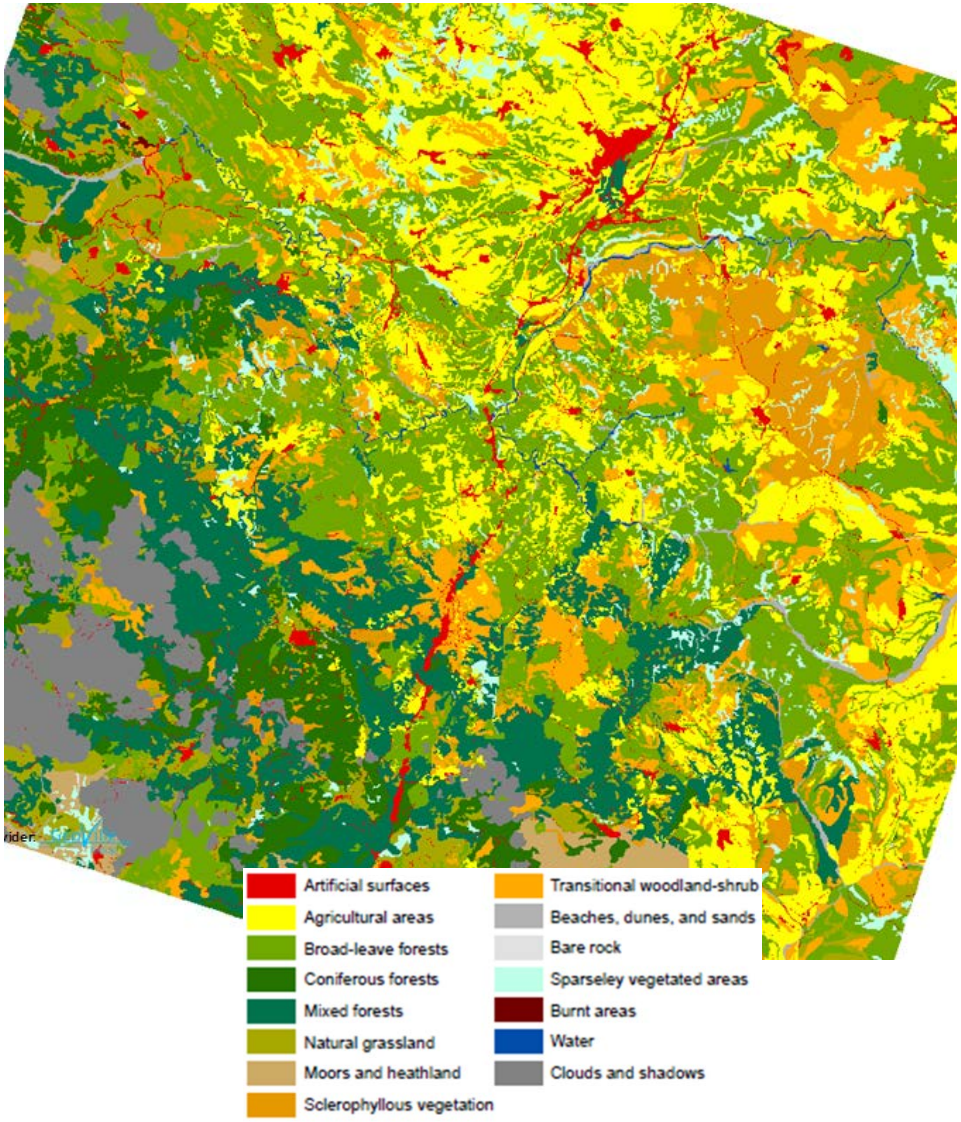
Monitoring mining impacts



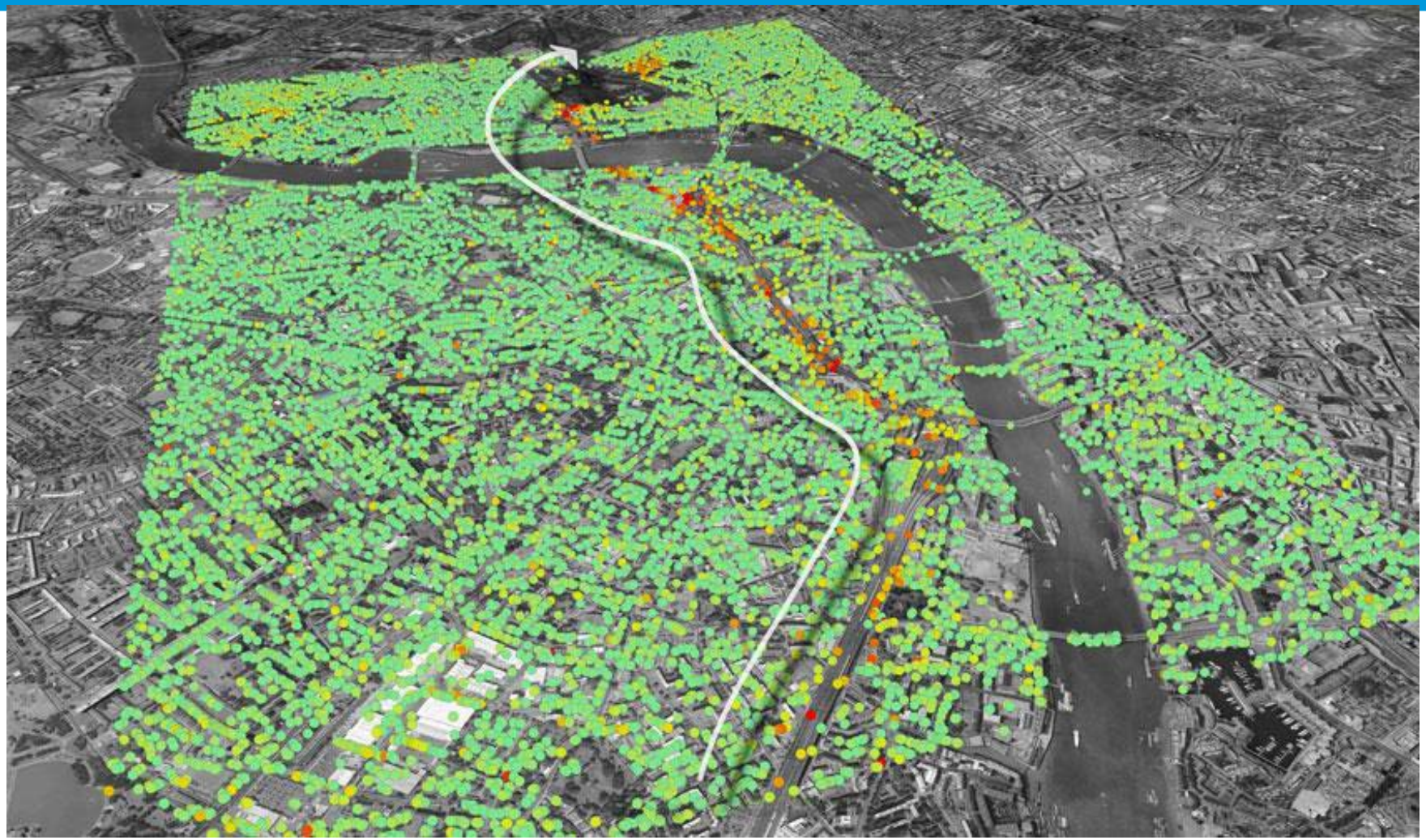




Impact & progress of construction projects



Impact of tunnelling

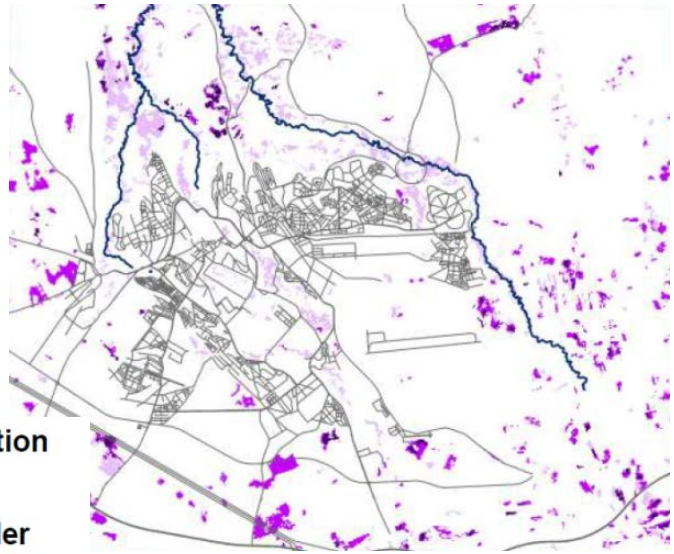


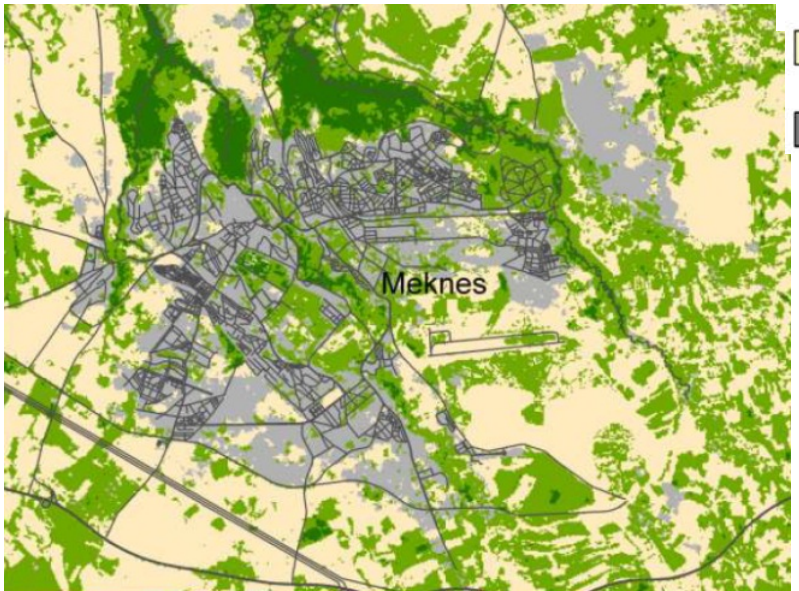
Monitoring overall impact of completed projects

Illustrative examples

1. Changes in agricultural practices resulting from investment in improved irrigation in Morocco
2. Water quality in coastal areas resulting from improvement projects
3. Impacts of Palm Oil Development Project in PNG
4. Impact of Marine Highway implementation in West Indian Ocean with respect to contamination of coral habitats

Impact of irrigation improvement





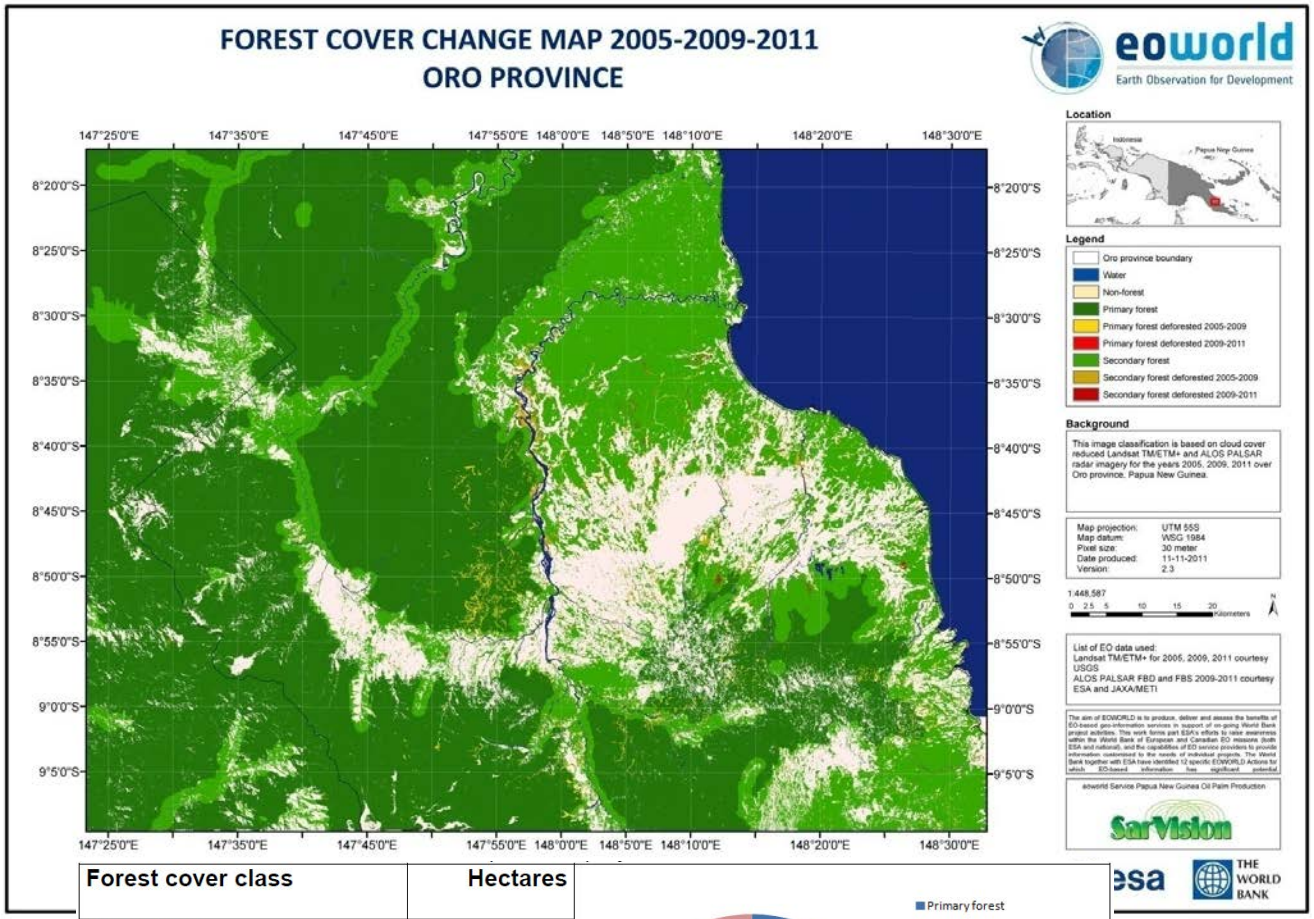
Pasture, tree cultivation and orchads

Extensive crops under irrigation

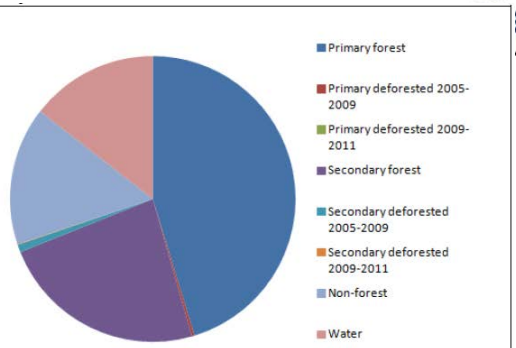
Bare soil (agrarian use)

Urban and industrial areas

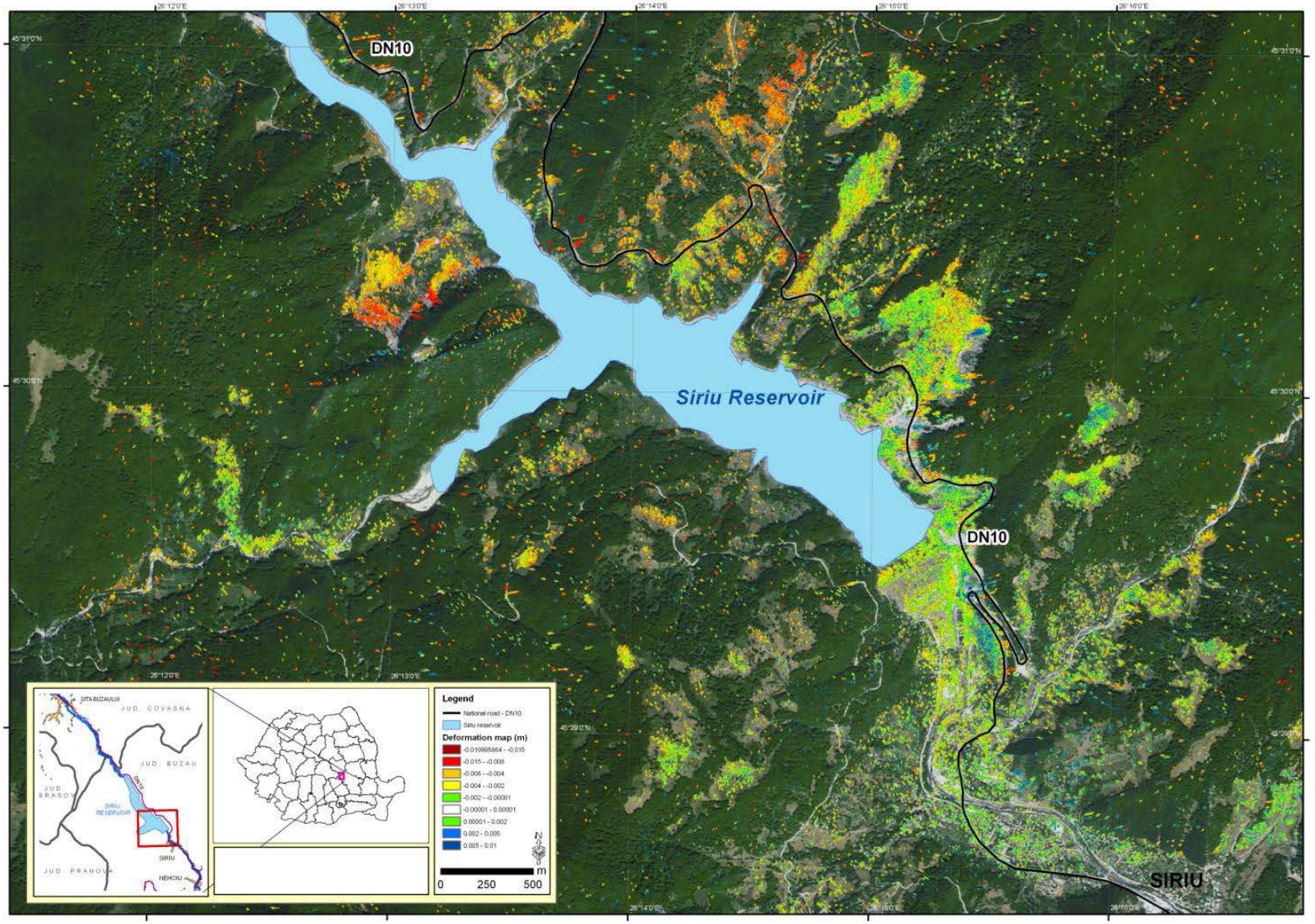
Palm oil



Forest cover class	Hectares
Primary forest	556,893
Primary deforested 2005-2009	3,832
Primary deforested 2009-2011	22
Secondary forest	286,963
Secondary deforested 2005-2009	10,712
Secondary deforested 2009-2011	915
Non-forest	192,480
Water	178,014



Impact of dam construction



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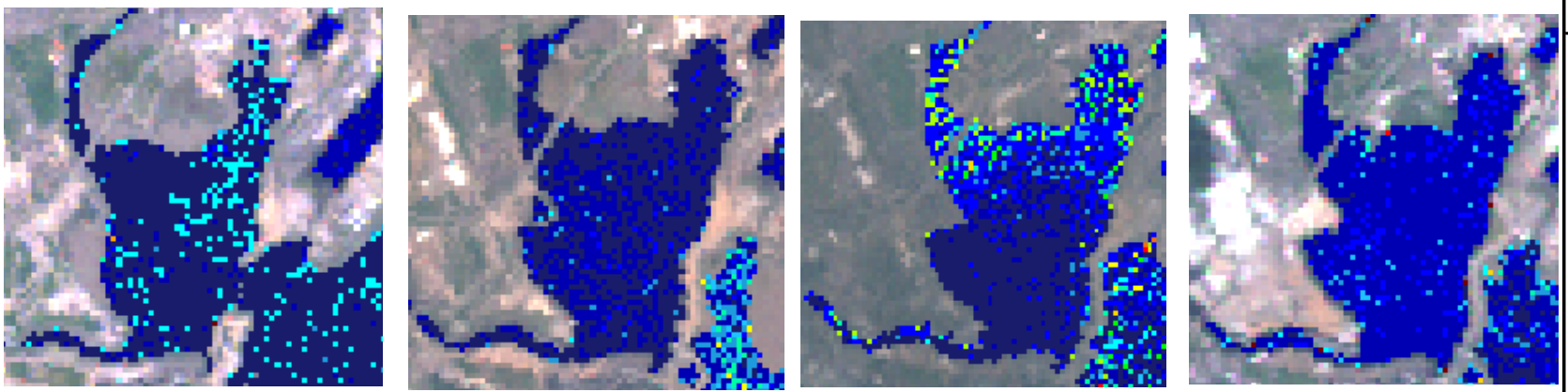
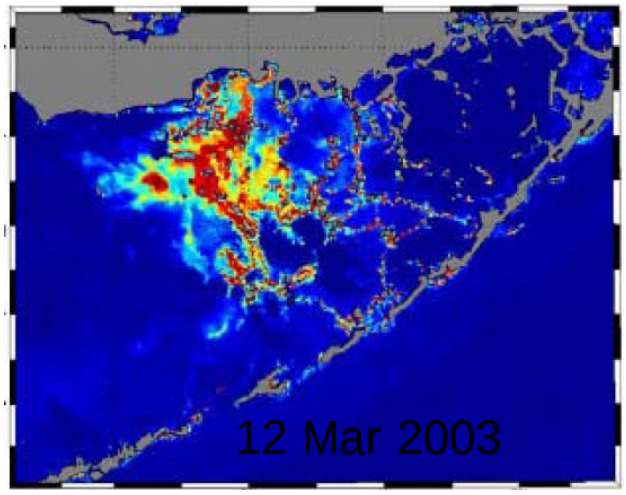
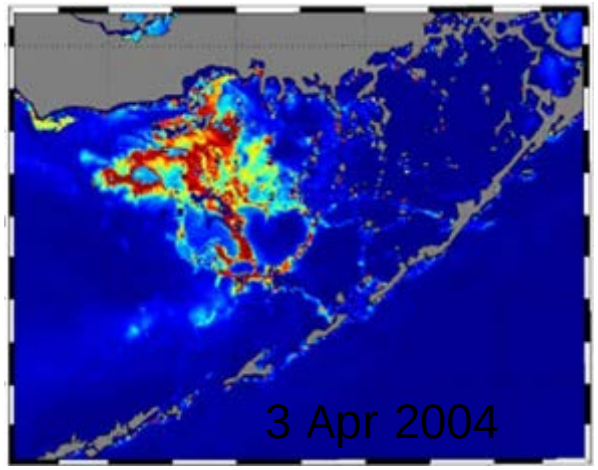
Water quality improvement projects

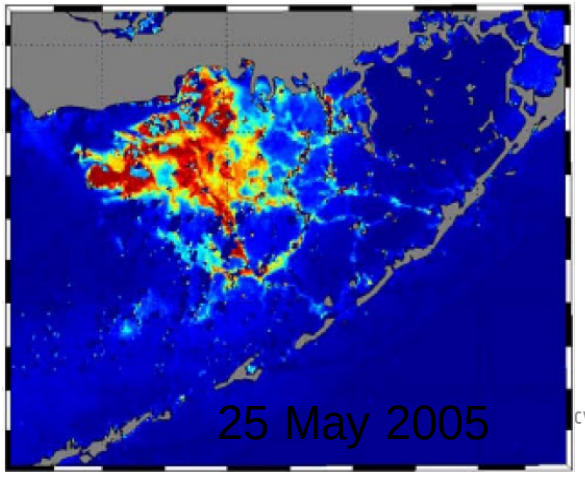


1998 2000 2002 2004

March 2003 April 2004 May 2005





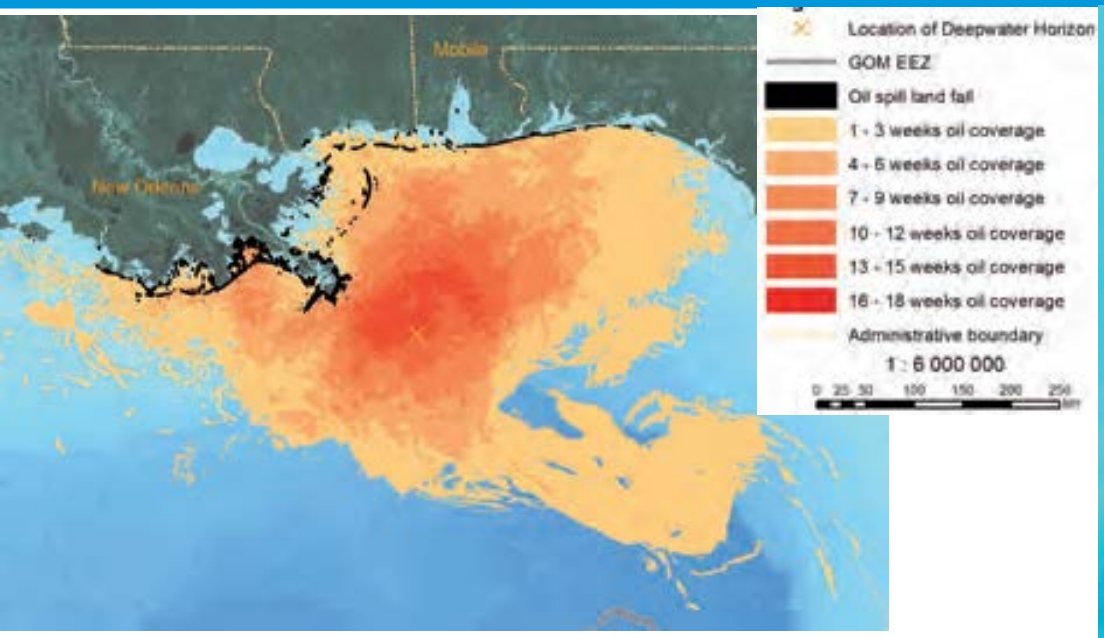


Characterisation of impact of one-off events

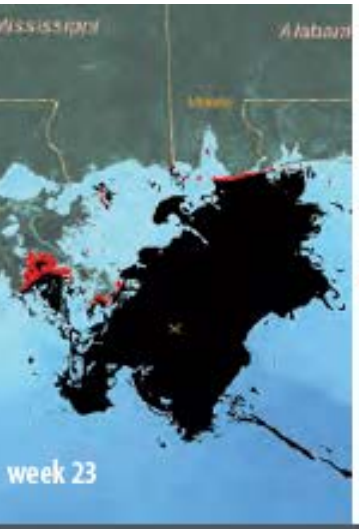
One-off events (usually accidents / natural disasters)

1. Typical situation:
    a. Rapid characterisation of changes of interest
    b. Lower resolution to ensure appropriate covered
    c. Later analyses provide higher resolution, finer scale analyses
2. Key considerations:
    - Is there a reference baseline?
    - If not, are historic data available to support the construction o a reference baseline
    - What are the impacts to be measured
    - Have sufficient data been collected around the event to enable a credible characterisation of the consequences
3. Illustrative examples:
    a. Habitat contamination from Deep Water Horizon leak
    b. Damage assessment from flood/landslide events

Example - DWH

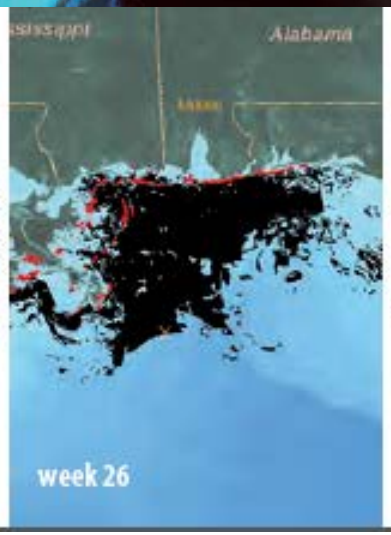

Mobile
New Orleans

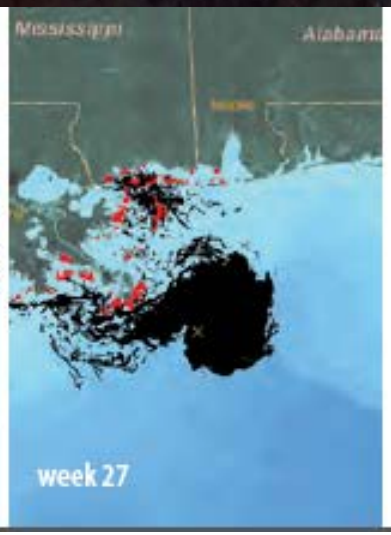
Location of Deepwater Horizon
GOM EEZ
Oil spill land fall
1 - 3 weeks oil coverage
4 - 6 weeks oil coverage
7 - 9 weeks oil coverage
10 - 12 weeks oil coverage
13 - 15 weeks oil coverage
16 - 18 weeks oil coverage
Administrative boundary
1 : 6 000 000
0 25 50 100 150 200 250


week 23


Alabama
week 24


Alabama
week 25

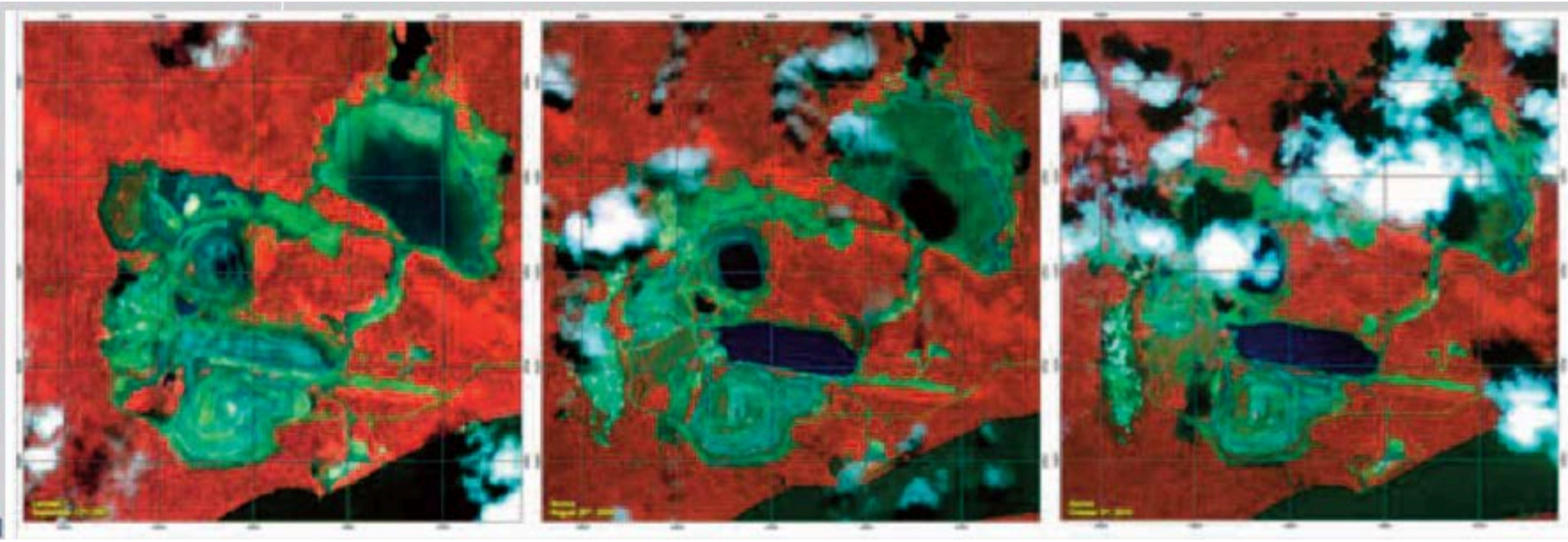

Alabama
week 26


Mississippi
Alabama
week 27

Monitoring compliance with remediation obligations

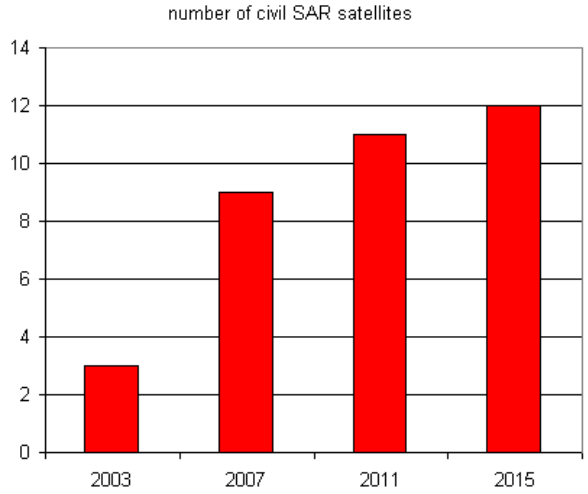
Remediation obligations

1. Both parties have vested interest:
    - Project implementation organistation (eg mining company) – “it wasn’t us”
    - Regulatory body – “ensure complance”
2. Satellite derived information ensures independent information source



A note on the underlying technologies

Evolution in satellite observing capabilities



EVOLUTION IN OBSERVING PERFORMANCE

	2000	2015
Spatial resolution	10m	0.5m
Update times (days)	3-10	0.5
Tasking time (hours)	96	3-6
Latency (hours)	12-24	0.2-3

	Satellite Data	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Existing missions	ERS/Envisat SAR																																		
	Radarsat 1/2																																		
	Cosmo-Skymed																																		
	TerraSAR X/Tandem X																																		
	ALOS																																		
	RISAT 1																																		
	SPOT/Pleaides																																		
	Landsat TM																																		
	RapidEye																																		
	Sentinel 1 (SAR)																																		
Missions under development	ALOS 2																																		
	Paz																																		
	SAOCOM																																		
	Sentinel 2 (optical)																																		
	Sentinel 3																																		
	Radarsat Constellation																																		
	TerraSAR 2																																		
	Enmap																																		

Conclusions

- EO derived information can support consistent change detection as an input to impact assessment over a wide range of
  - Time-scales
  - Spatial scales
  - Coverage
  - Environmental situations
- Where EO derived information does not provide total characterisation of the indicators of interest, it can provide important context:
  - Optimisation of in-situ data collection strategies
  - Understand spatial/temporal variations around in-situ sampling to ensure representivity or extrapolate over wider area
- Increasing number of increasingly performant satellites ensures:
  - More comprehensive archives for reference epochs
  - Opportunity to characterise changes of interest over range of spatial scales and time scales/periods
- Main issues to address:
  - Awareness of EO capabilities in support of impact assessment
  - Establishment of best practice guidelines to integrate EO