

Emerging Pressure on Mangrove Forest Environments as a Result of Shrimp Farming Expansion – A Remote Sensing based Analyses for an Exemplary Coastal Site at the Pacific Coast in South America

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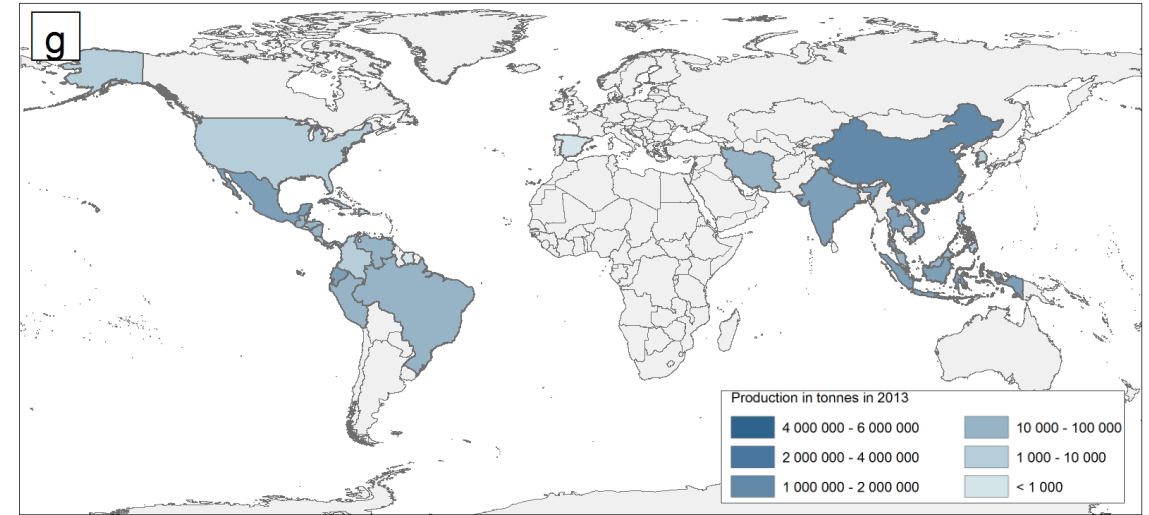
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A satellite image of the Earth showing the Pacific Ocean, South America, and parts of Africa and Europe. The text 'Knowledge for Tomorrow' is overlaid on the image.

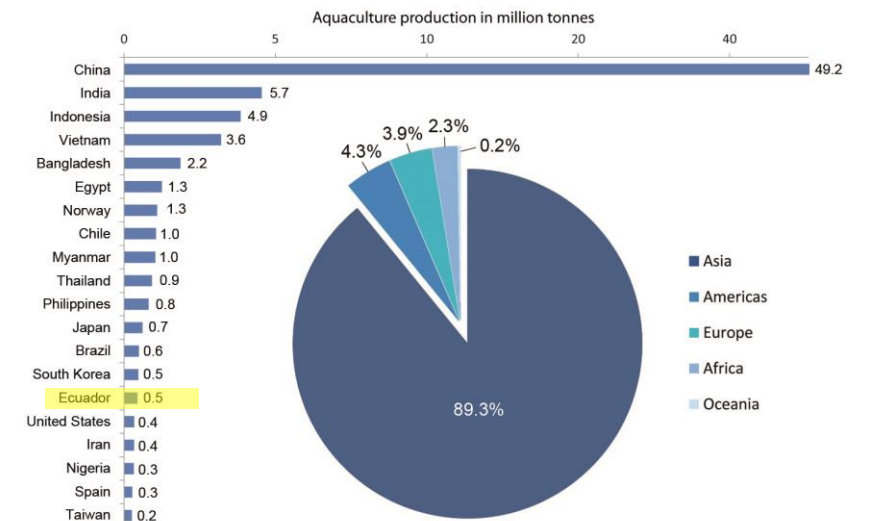
Knowledge for Tomorrow

Background: Aquaculture

- Aquaculture is a major protein source and important for food security
- Latin America and Southeast Asia are the largest producers of farmed shrimp in the world (FAO)



Production of Whiteleg shrimp in t by country. Data source: FAO (2015).



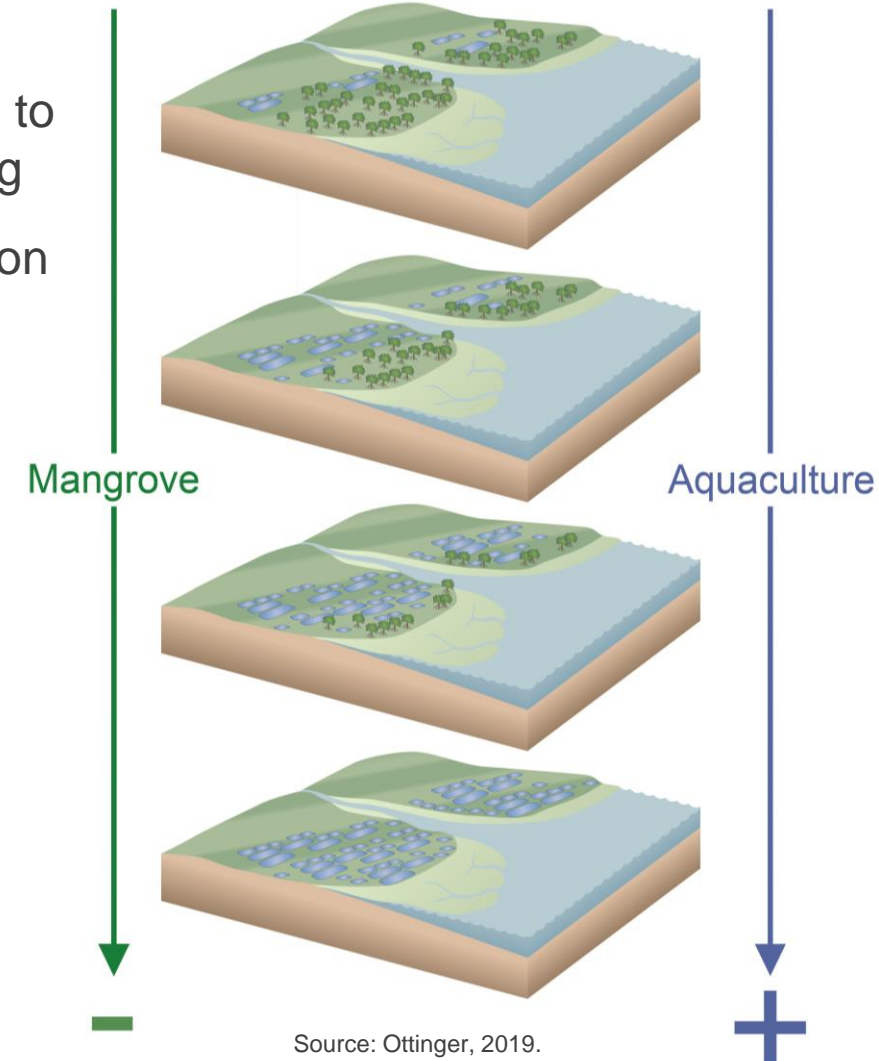
Global total aquaculture production of top 20 producers (bar chart) and share among continents (pie chart). Data source: FAO (2017)

Aquaculture Expansion & Mangrove Loss

- Aquaculture development is transforming coastal ecosystems and leads to environmental degradation and conversion of wetlands to shrimp farming
- Mangrove deforestation in the course of coastward aquaculture expansion

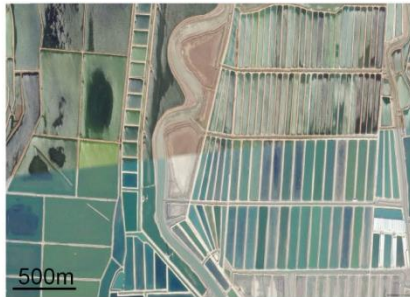


Exemplary photos of shrimp ponds with aeration systems in Vietnam. Source: DeltAdapt project, 2017.



Source: Ottinger, 2019.

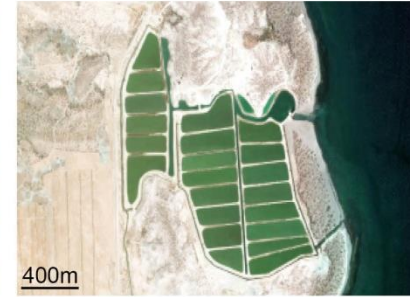
Pond Aquaculture in Earth Observation Data



Fish farms, China



Fish farm, Uganda



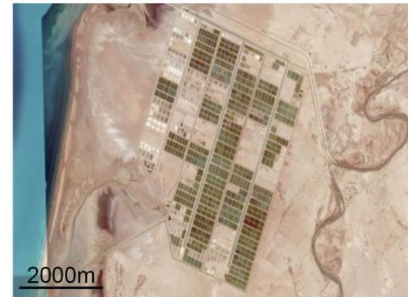
Shrimp farm, Mexico



Shrimp farm, Malaysia



Shrimp farm, India



Shrimp farm, Iran



Shrimp ponds, Ecuador



Fish farms, China



Raceway system, Peru



Aquaculture ponds, Vietnam



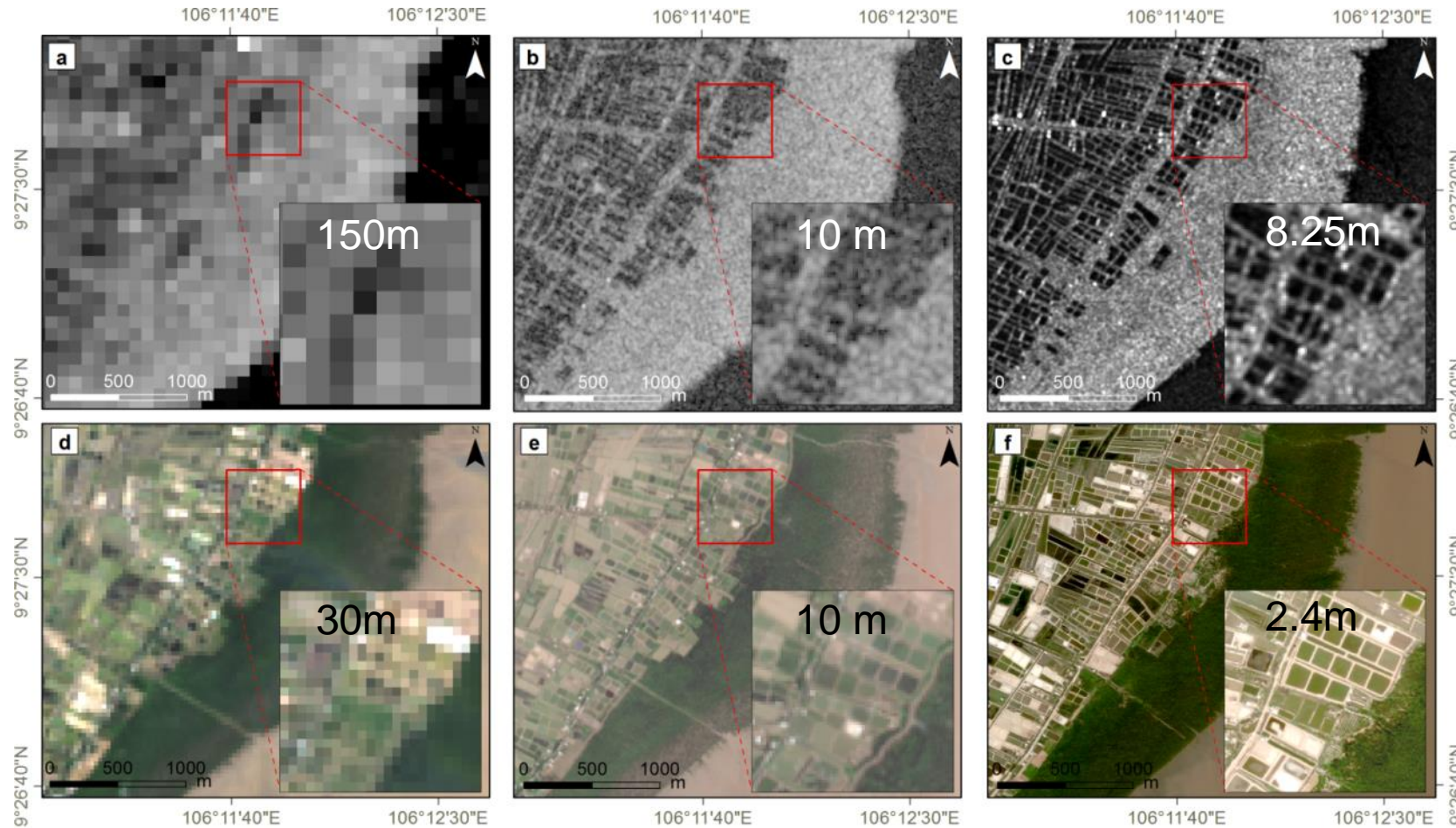
Aquaculture ponds, Thailand



Aquaculture ponds, Indonesia

Images of different aquaculture production systems (cages, raceways, ponds). Image source: Google Earth.
Modified according to Ottinger et al. (2016).

Potential of Spaceborne Earth Observation



SAR sensors

- a - Envisat ASAR
- b - Sentinel-1
- c - TerraSAR-X

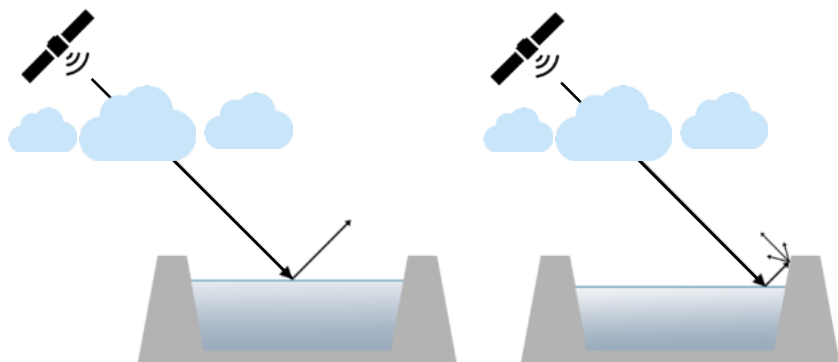
Optical sensors

- d - Landsat
- e - Sentinel-2
- f - Quickbird-02

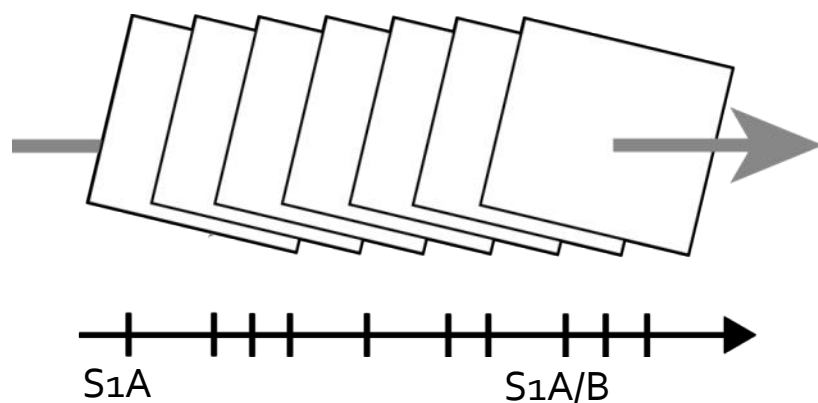
Source: Ottinger et al. (2018): Opportunities and Challenges for the Estimation of Aquaculture Production based on Earth Observation Data. Remote Sensing. 10 (7), 1076.



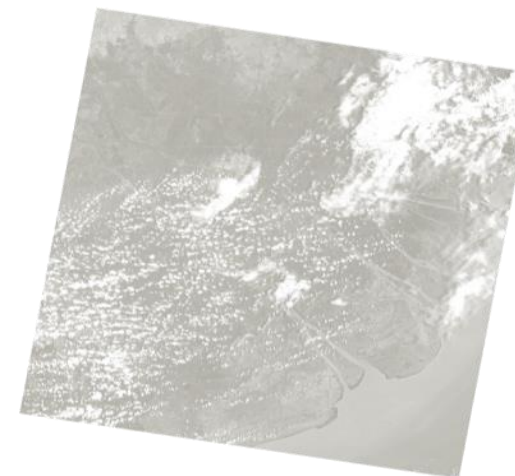
Potential of SAR Data



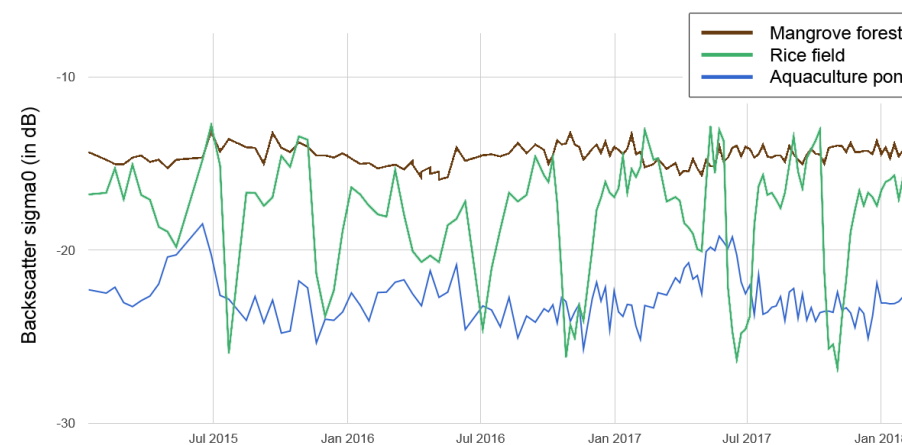
SAR backscatter characteristics of pond systems
(water: diffuse reflection; dams: corner reflection)



Dense time series (e.g. Sentinel-1 mission)



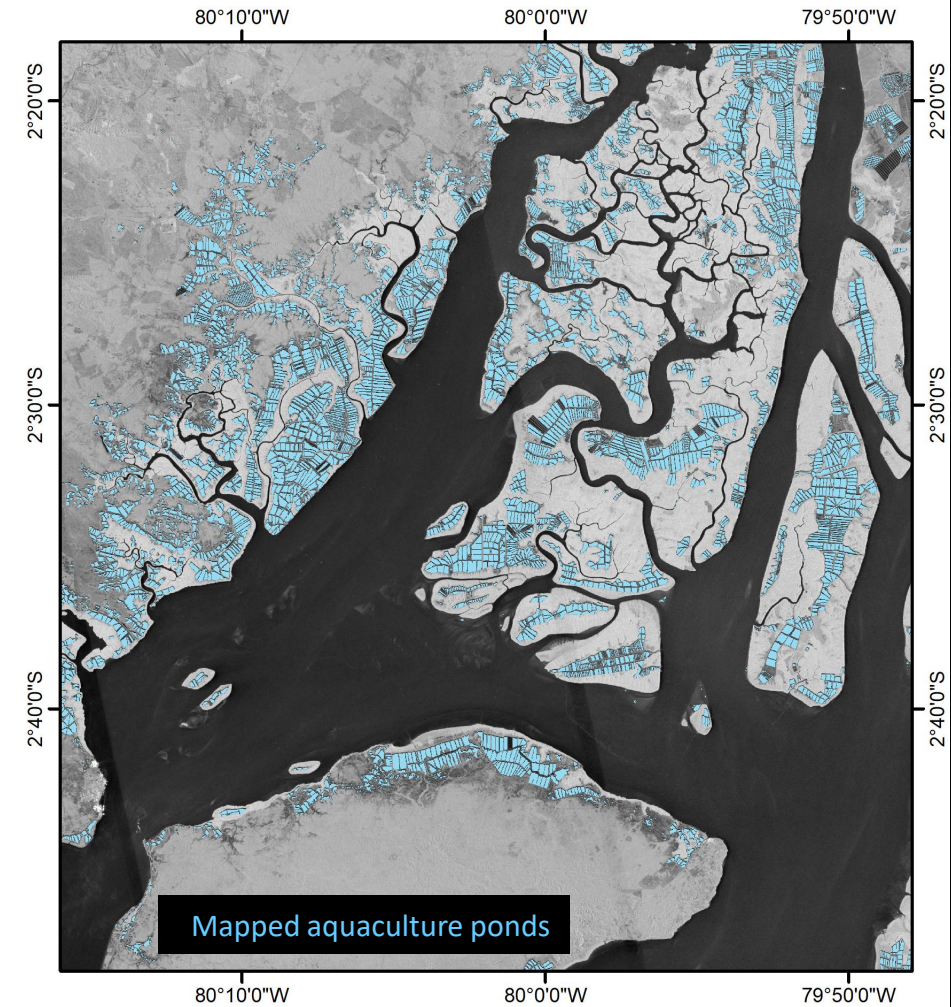
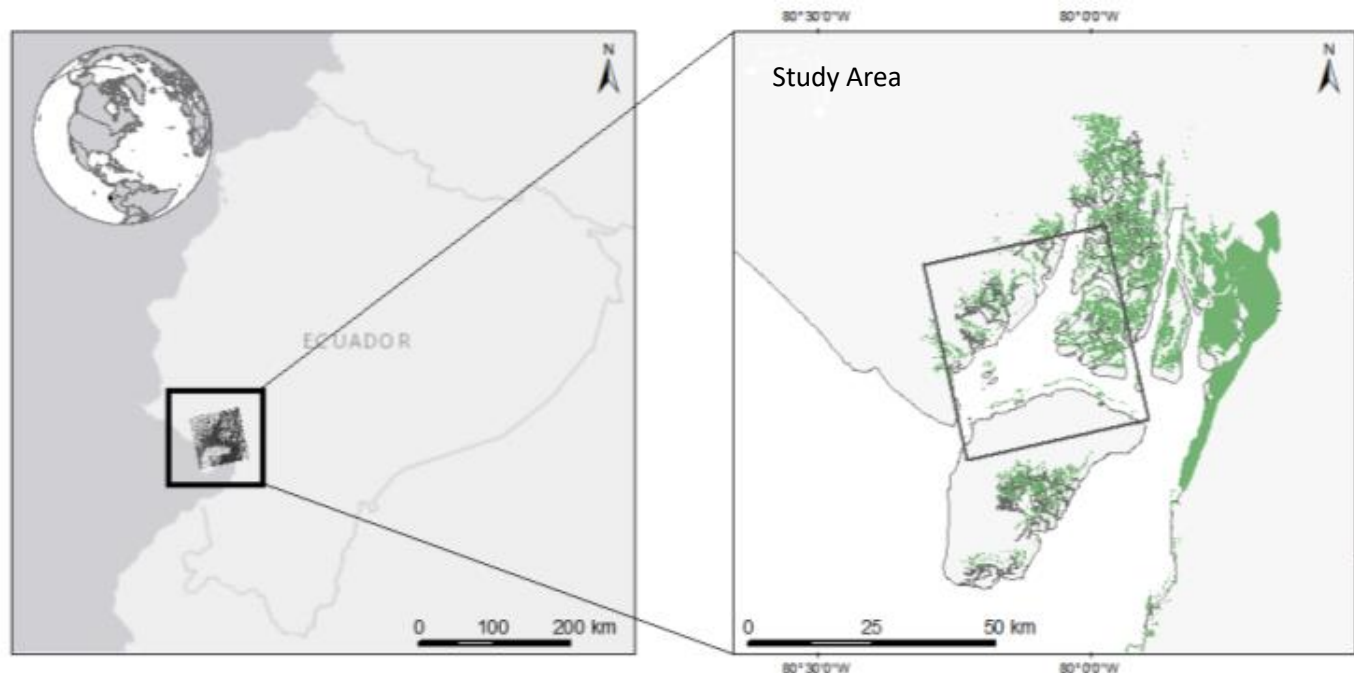
Cloud independence → improved monitoring capabilities
in cloud-prone coastal areas (tropical regions)



Derivation of SAR temporal signatures

Automatic Shrimp Pond Extraction with SAR Time Series

- Aquaculture processor for automatic extraction of aquaculture ponds in coastal regions with C-Band and L-Band SAR time series data
- Histogram-based water thresholding and image segmentation based on shape features to map rectangular shrimp ponds



Result of shrimp farm mapping with C-Band SAR data
SAR time series data: Sentinel-1A, IW-GRDH, VV-dualpol, 10m pixel spacing, Year 2015



Deforestation

Aquaculture ponds in coastal mangrove environment
Location: Gulf of Guayaquil, Ecuador
© Google



BY

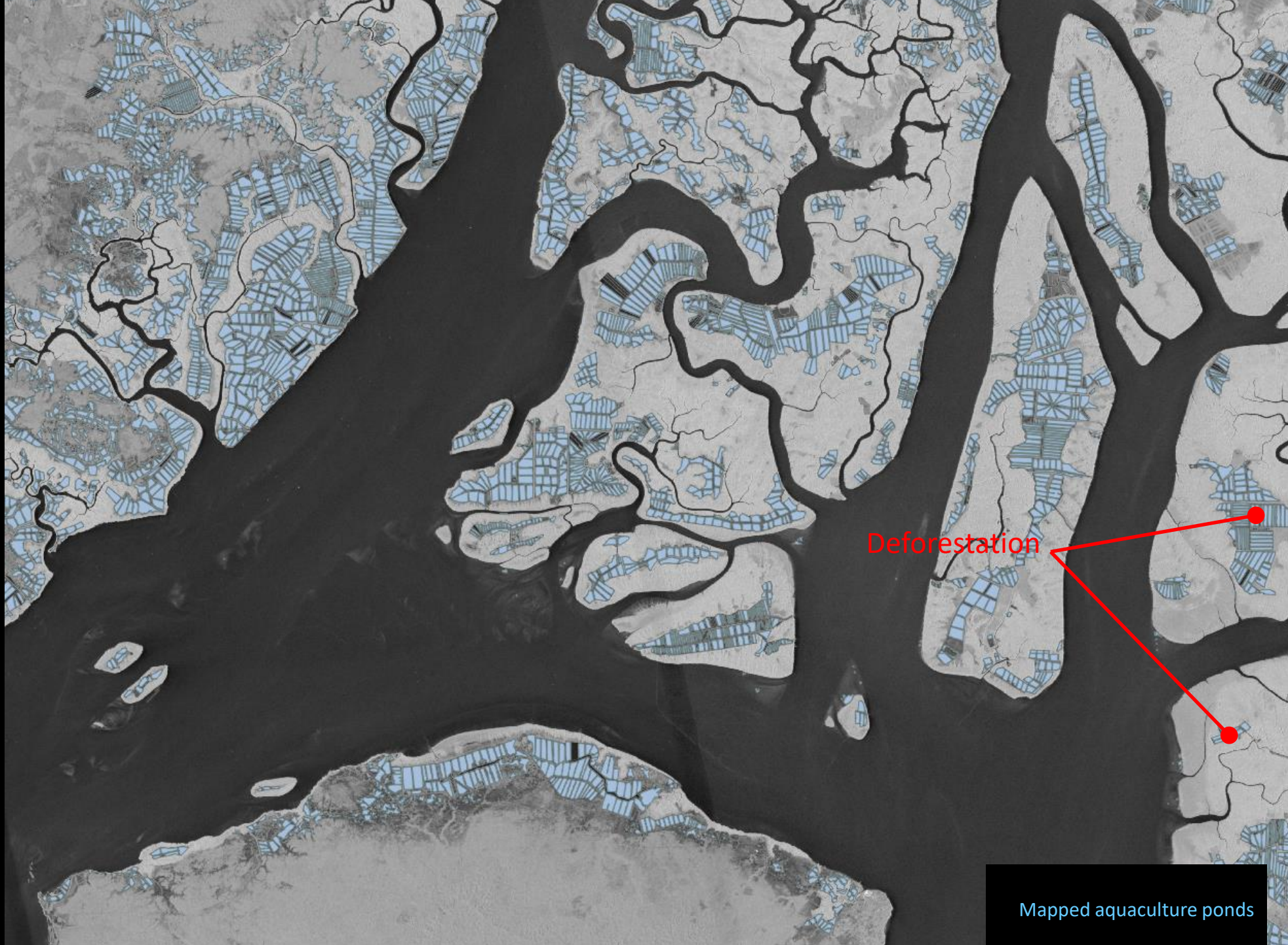


Deforestation

Sentinel-1A, IW-GRDH
VV, 10m Pxl spacing
Year 2015

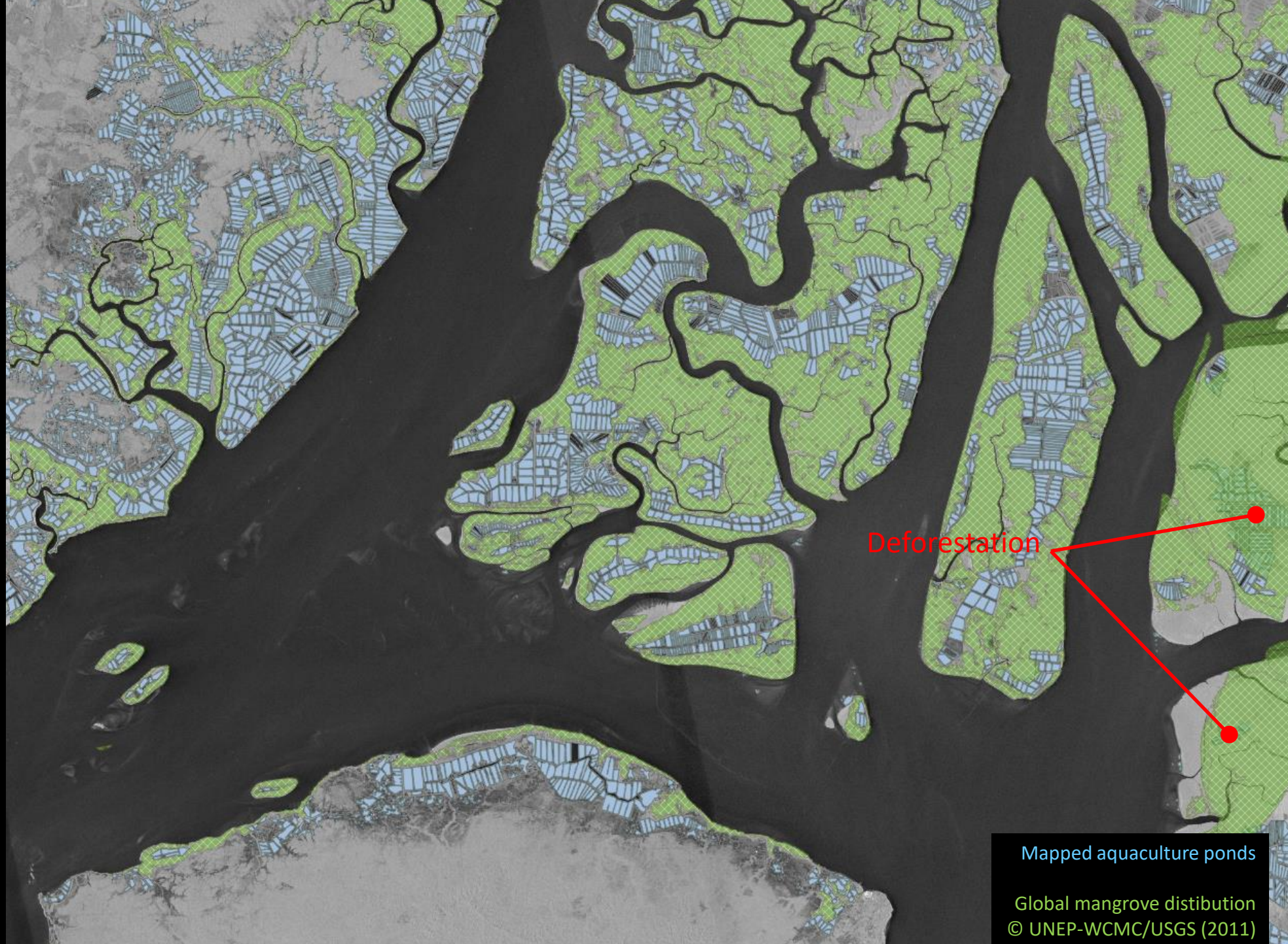


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Deforestation

Mapped aquaculture ponds



Deforestation

Mapped aquaculture ponds

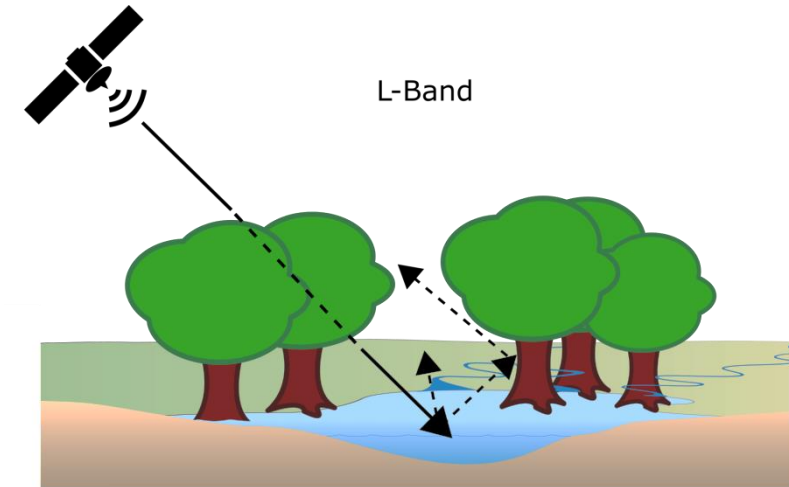
Global mangrove distribution
© UNEP-WCMC/USGS (2011)



Outlook

Mangrove forest mapping and monitoring with L-band SAR

- Sensitivity of SAR signals to vegetation structure; scattering mechanism in mangrove forest strongly depends on canopy structure
- Better canopy penetration capabilities with long wavelength SAR
→ detection of flooded vegetation and wetlands (mangroves)



Impact analysis

- Loss of resources (mangrove area)
- fragile surrounding areas (e.g. freshwater resources)
- Rate and amount of land use changes



References

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