Understanding cause-impact relations through remote sensing to support water quality policy in the Bolivian Andes

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Painting the picture

- Bolivian Andes

- Most populated basin in the country
  - 11% of Bolivians in 0.27% of territory
  - ~ 1 million inhabitants

- Mining, urban growth, industries, agriculture: Affecting water quality
  - Discharges into Lake Titicaca

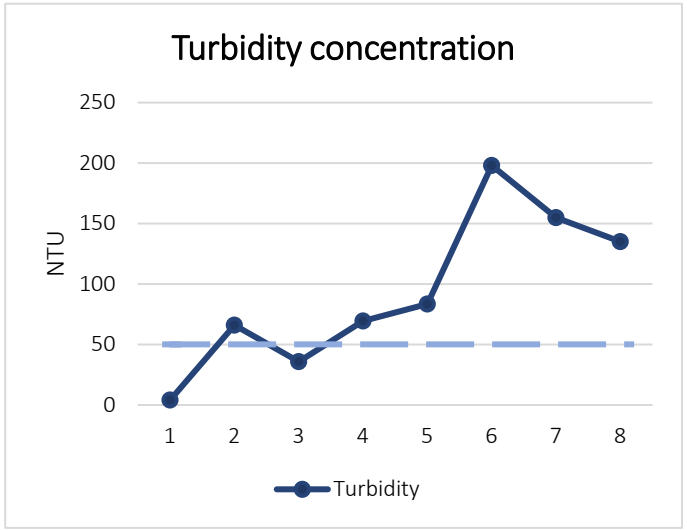
Things are bad, but how bad?

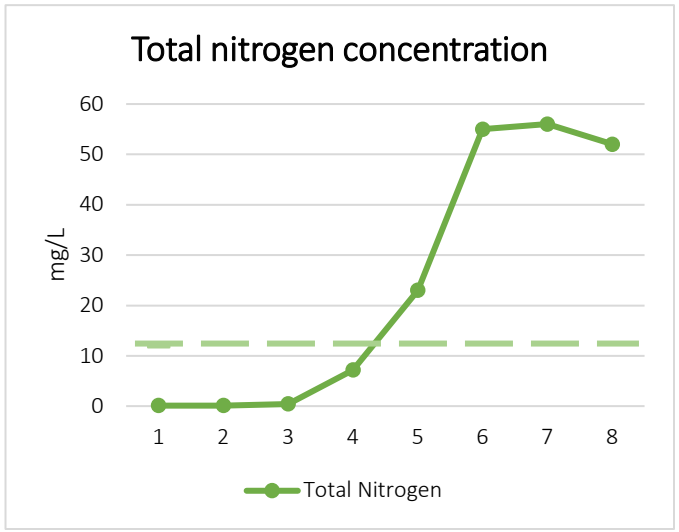
- Current water quality monitoring system:
  - Infrequent and scattered
- No trends or patterns can be detected
  - Data is not conclusive
- Difficulty in developing targeted public policies

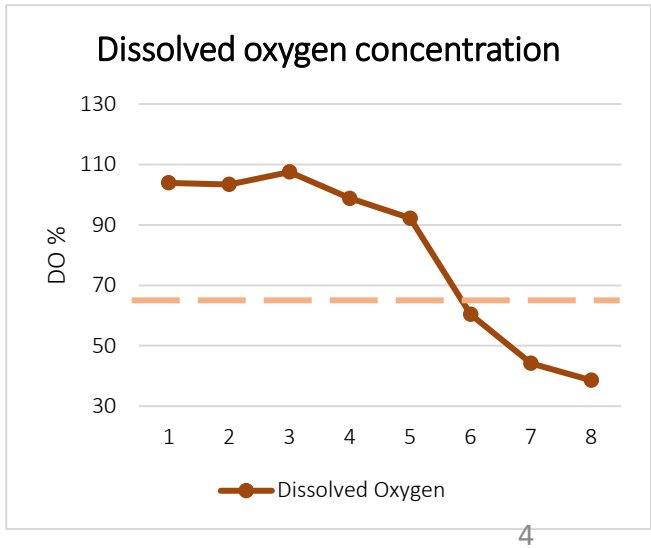
2015

What does the existing data say?

- Quality of water in rivers worsens as they flow through cities
  - Behavior detected in other parameters: COD, BOD, Fecal coliforms, Nitrates, Sulfates, SPM

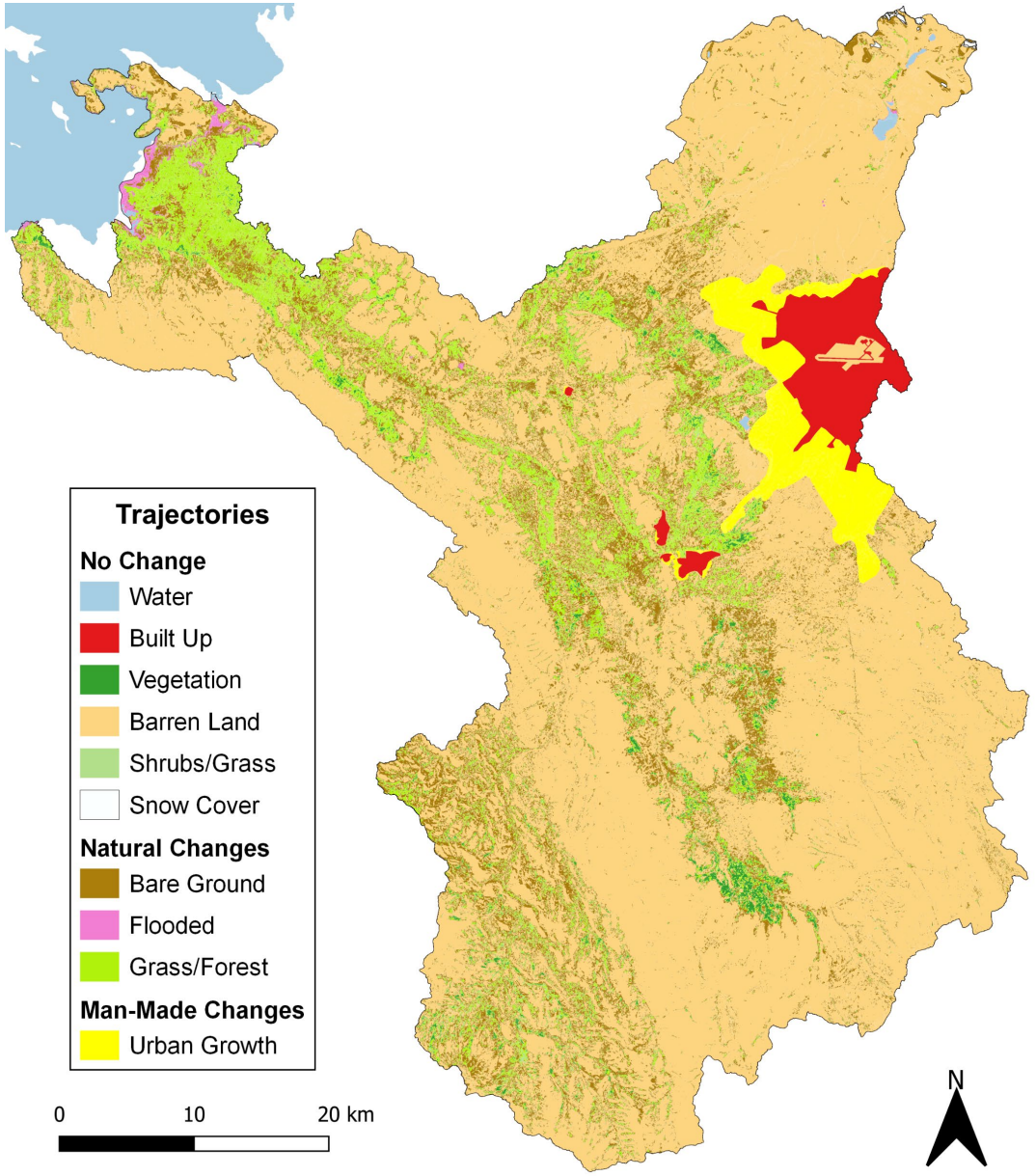






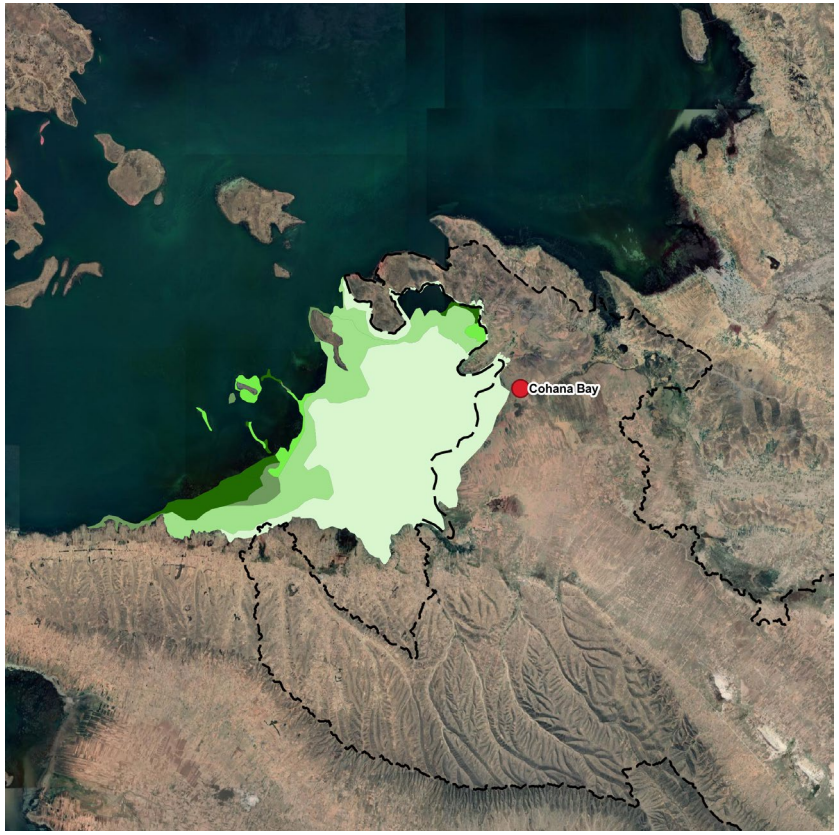
Fast urban growth, but how does that look like?

- Land cover classification
  - 3-year time step from 2006 to 2018
  - Landsat 7 - dry and wet seasons
  - Preprocessing and DOS1 atmospheric correction
  - Unsupervised classification – 6 classes
  - Accuracy analysis
- Trajectory analysis
  - Pixel history
  - Dry season images

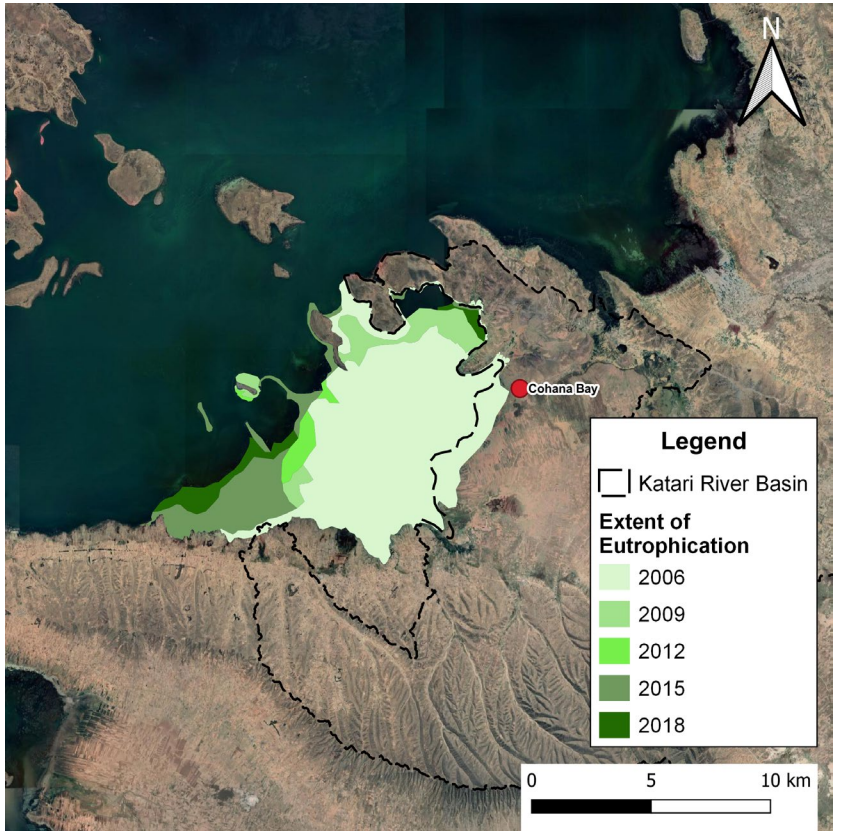


123% expansion of urban areas
increasing trend ($p < 0.05$) at a rate of 8 km^2/year

What other evidence we have?



Dry season

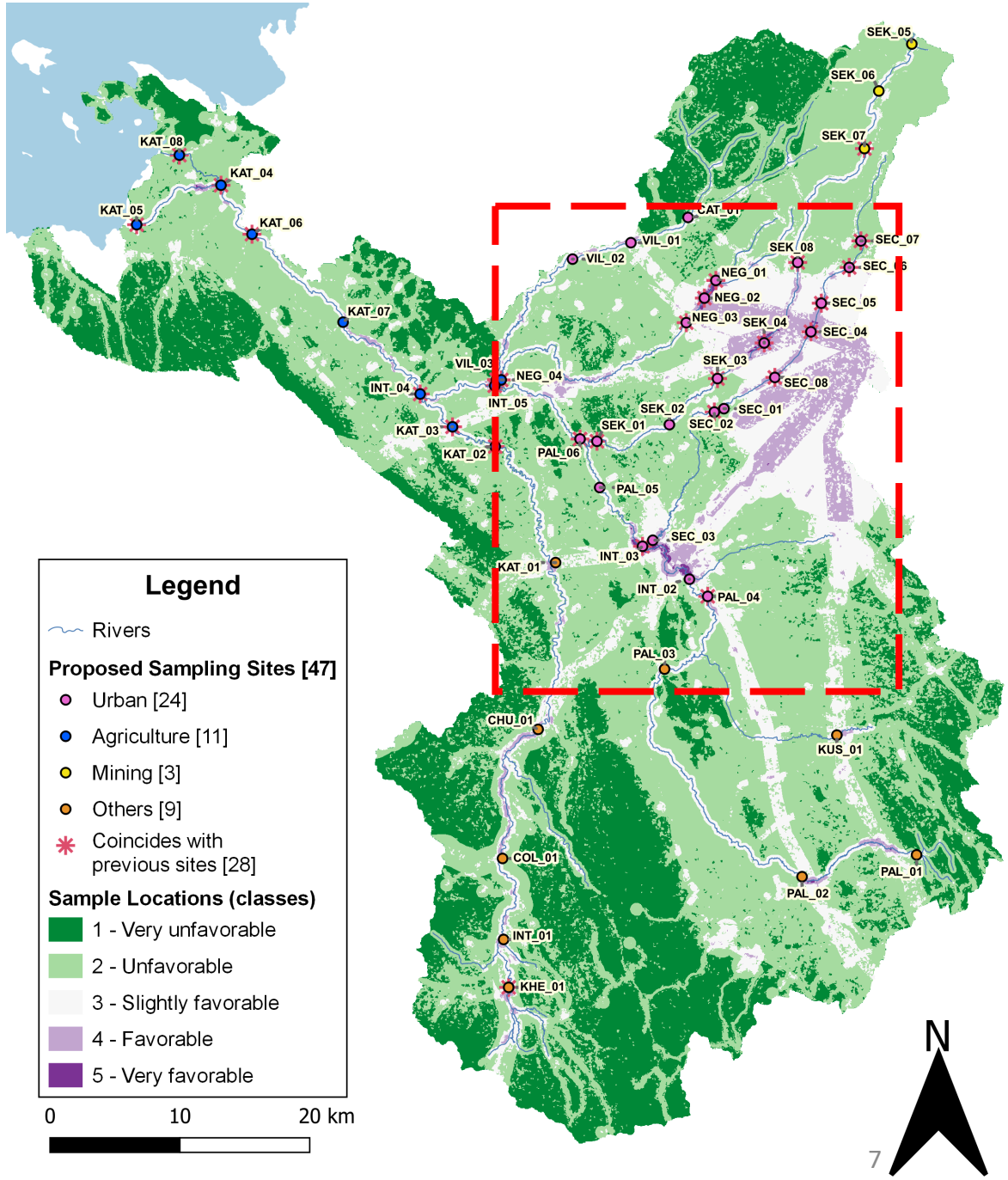


Wet season

- NDVI, NDAVI & SAVI used as proxy for eutrophication – Landsat 7
- 1.7 km^2/year of eutrophicated areas was calculated
- Chlorophyll-a & turbidity – Sentinel 2

Design of new monitoring system

- Based on ministry's objectives
- Efforts to continue with historic measurements
- Analytic Hierarchy Process:
  - Anthropogenic, physiographic & water quality aspects
- Areas with highest classification: coincide with urban (growth) areas
- Sampling parameters & frequencies
  - Based on land uses



In summary

- Trajectory map used to monitor urban growth
- For every 4.8 km^2 of urban built-up area, the extent of eutrophicated areas in Lake Titicaca's shores increased by 1 km^2 on average (1:5 ratio)
- Remote sensing used to relate land cover changes and eutrophication

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