Relevance of the land use changes related to a megacity development in a Colombian river basin

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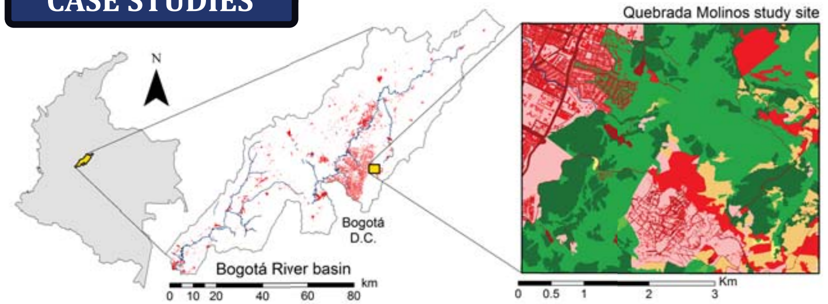
INTRODUCTION

- **Megacity development** (e.g. Bogotá) → main driving force for **land uses changes**
- Population rise depends on the natural resources available in the occupied area:
  - **Water** → pivotal requirement
- Science gap: **interactions between land-use change and hydrologic processes** will be a major issue in the decades ahead (DeFries and Eshleman, 2004)

CASE STUDIES



Land uses (CORINE Land Cover classification system, level 2)

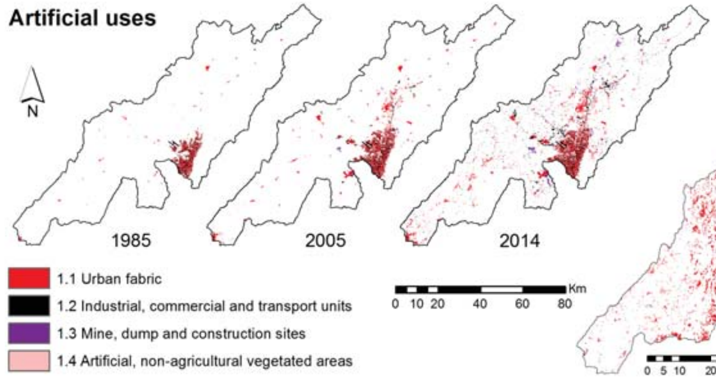
- 1.1 Urban fabric
- 1.2 Industrial, commercial and transport units
- 1.3 Mine, dump and construction sites
- 1.4 Artificial, non-agricultural vegetated areas
- 2.1 Arable land
- 2.2 Permanent crops
- 2.3 Pastures
- 2.4 Heterogeneous agricultural areas
- 3.1 Forests
- 3.2 Scrub and/or herbaceous vegetation associations
- 3.3 Open spaces with little or no vegetation
- 4.1 Inland wetlands
- 5.1 Inland waters

Bogotá River basin → 5472 km² drain to the Bogotá River that flows 270 km (SW) from 3400 to 280 m.a.s.l. (Magdalena River)

- Upstream: cold highlands (Sabana)
- Downstream: alluvial plain surrounded by folded mountains

Quebrada Molinos study site → eastern periphery of Bogotá megacity

LAND USE CHANGE ANALYSIS



Bogotá River basin (period 1985-2014)

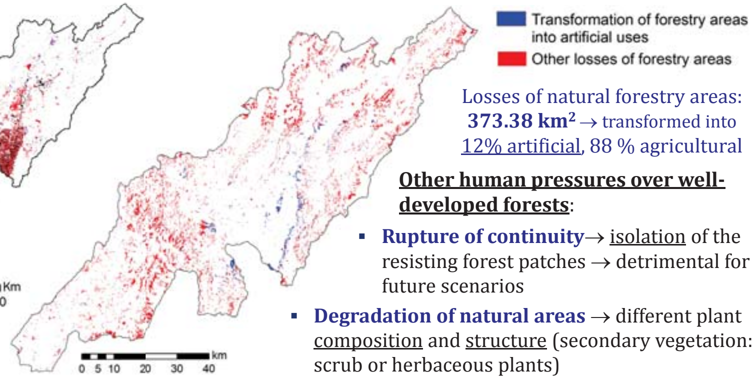
Land use changes → 3061.56 km² (**55.95 % basin surface**)

- **Transformations into artificial uses:**

  Agricultural lands and forests → **416.28 km²** (13.6 % of land use changes)

  - heterogeneous agricultural uses and pastures → important role in the urbanization process (88.96 % of the change into artificial surfaces)
  - natural forestry area lost → 44.55 km² (68.4 % dense forests, 9.4 % páramo ecosystems, 22.2 % open spaces with little or no vegetation)

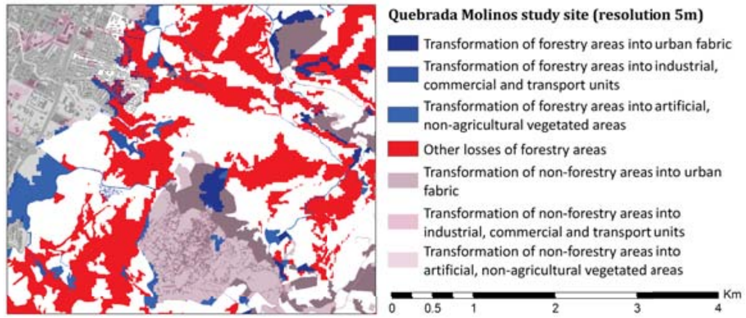
Importance of forest fragmentation under human pressures



Losses of natural forestry areas: **373.38 km²** → transformed into 12% artificial, 88 % agricultural

Other human pressures over well-developed forests:

- **Rupture of continuity** → isolation of the resisting forest patches → detrimental for future scenarios
- **Degradation of natural areas** → different plant composition and structure (secondary vegetation: scrub or herbaceous plants)



IMPLICATIONS IN DISTRIBUTED HYDROLOGICAL MODELLING

Highlights relating land use changes and water resources management:

Anthropogenic land use changes: main driver for hydrological changes (alterations in streamflow patterns) → URBANIZATION (most forceful)

- **Increase of agricultural and urban uses** → changes in water demands (artificial and agricultural uses requirements)
- **Reduction in forest cover** → decrease in evapotranspiration and groundwater recharge → increase in discharge and flood peaks
- Need of advanced tools for water resources management (spatially distributed hydrological modelling able to consider these land use changes)
  - **Mathematical modelling for a reliable prediction of the hydrological effects related to land-use changes** is in an early stage of development (Beven, 2000) → rational method / USDA-SCS curve number approach (widely used to explain hydrological response of land use changes)
  - **Landsat imagery** provide spatial distribution of land coverages → large areas, frequent time intervals → changes can be analyzed (Hansen *et al*, 2013)

Hydrological modelling → parameters related to land use determine the hydrologic variables

Approach: Proposed changes to be implemented in the **TETIS distributed hydrological model** (Francés, Vélez and Vélez, 2007):

- **Land use parameters** → I_{max}, λ_v, Hu, k_s → consideration of **two sets of parameters**: **urban** (including industrial, commercial, transport and any other land cover with low permeability and evapotranspiration capacity) and **non-urban** including forestry areas, agricultural lands and other artificial vegetated areas.
  - Each set of parameters should be calculated considering the surface occupied by each type of uses in the cell (**proportion of the different urban uses** in the first set, **proportion of the non-urban uses** in the second set)
- **Hydrological fluxes** → calculated separately for urban/non-urban and **weighted** after by the proportion of **urban/non-urban land cover**

CONCLUSIONS

1. Knowledge on land uses (cover distribution and characteristics) and its integration in hydrological modelling approaches leads to an efficient management of water resources
2. Extrapolating results to other systems can be challenging → Better option: focus efforts in developing robust and friendly methodologies/tools for the analysis of each case study
3. Reliable future scenarios can be provided for management by combining land use change analysis and the proposed distributed hydrological modelling approach

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