HOW DOES THE SPATIAL DISTRIBUTION OF GREEN WITHIN CITIES IMPACT CARBON FLOWS? A EUROPEAN SCALE ANALYSIS

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OUTLINE

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2. Research Question
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CONTEXT

CITIES

Demographic trends

1950
746 billions

→

2014
3.9 billions

→

2050
+2.5 billions

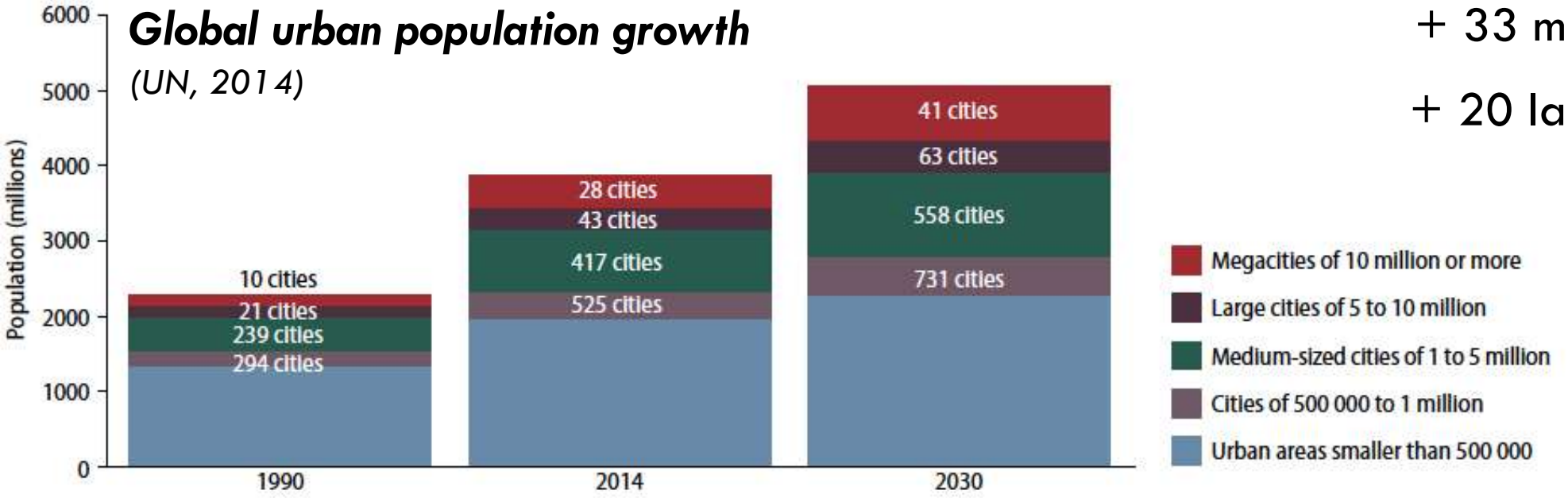
By 2030

+ 33 megacities (10b +)

+ 20 large cities (5-10b)

Global urban population growth

(UN, 2014)



CONTEXT

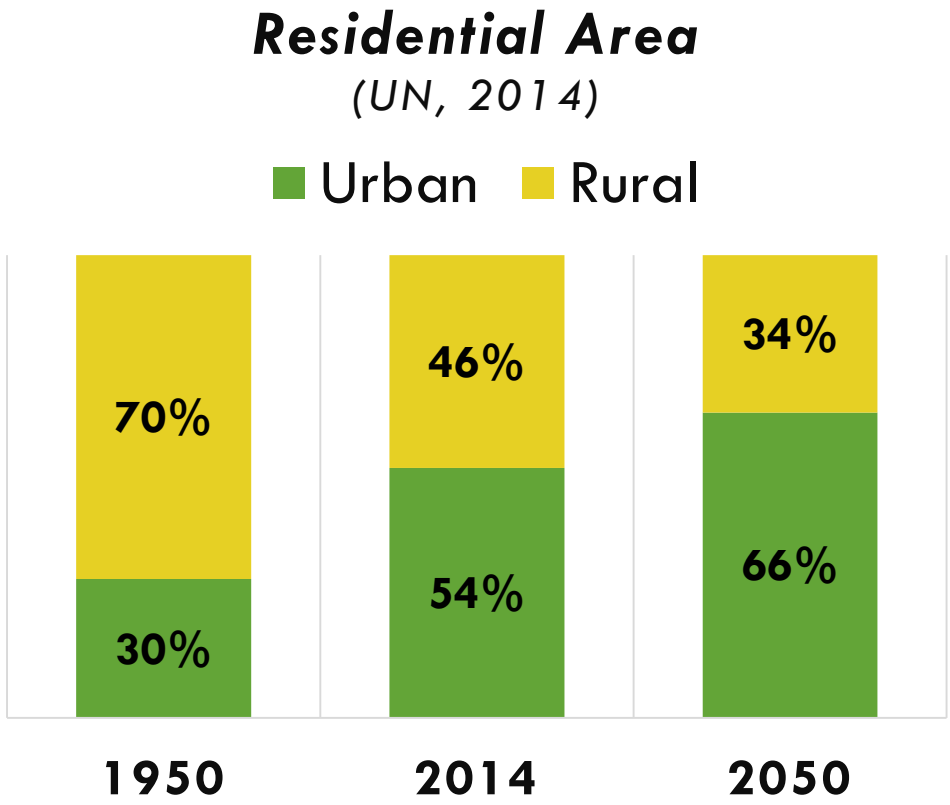
CITIES

Urbanization

- Estimates of total urban land area ranges from 0.2% to 3%, depending on the definition used. (Liu et al., 2014)

Soil artificialization

- Environment: destruction of natural habitats, heat island effect
- Climate Change: more extreme events, water infiltration issues

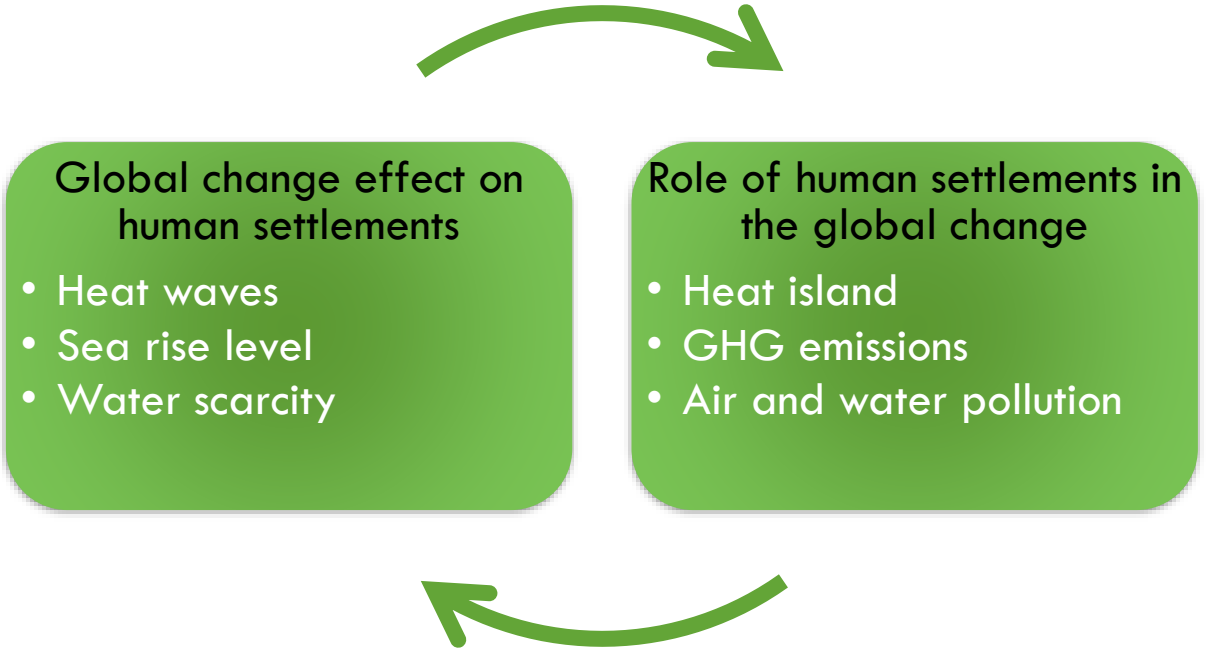


CONTEXT

CITIES, EMISSIONS

Gases and PMs concentration in the atmosphere

- Health: chronic respiratory diseases and premature death (Woodcock et al., 2009)
- Climate change: at local, regional and global scales
- 70% of the CO_2 emitted came from urban areas in 2006 (IEA, 2008)



Feedback effects between global warming and human settlements (Churkina, 2012)

CONTEXT

CITIES, EMISSIONS AND GREEN SPACES

Urban areas and sustainability

↓

Use of natural ecosystem services provided by urban vegetation

Emission of GHGs

- Local, regional and global warming
- Human health and mortality
- Well being
- Heat waves
- Extreme events

Emission of PMs

- Air/water pollution
- Human health and mortality

Human settlements

- Heat island effect
- Natural habitats
- Well being

RESEARCH QUESTIONS

CITIES, EMISSIONS AND GREEN SPACES

- Assess the **impact of spatial organization** of sources of emissions and carbon sinks
  - *Is **land sharing or sparing** more efficient? Under which conditions?*

- Understand and improve the **uptake capacity/dynamic** in urban environments by vegetation
  - *How **are urban carbon flows** impacted by the spatial organization at a "city" scale?*

- **Urban forest patterns** across Europe

LITERATURE REVIEW

URBAN VEGETATION

Carbon storage depends

- Lifespan
- Dimensions — **Species**
- Growth rate
- Urban stress resilience
- Photosynthesis rate — **Light, air temperature, N, water, O_3 concentration**

Churkina, 2012 - McPherson et al., 1993 - McPherson, 1994 - McPherson and Peper, 2012 - Nowak, 1994 - Nowak et al., 2002 - Scharenbroch, 2012

Advantages of the **Urban Forest**

- Filters emissions in the air and in the water
- Decreases the energy consumption
- Increases soil permeability
- Allows evapotranspiration
- Wanted amenity
- Accumulates biomass via photosynthesis process
- Exhibit more important physical constraints
- Different growth and longevity patterns

LITERATURE REVIEW
CARBON UPTAKE

Focus on the AGB (Above Ground Biomass), poor knowledge on the other natural sinks in urban environment

Carbon Stocks

- Allometric Equations
  - location specific, requires destructive harvesting, rely on field measurements, performs badly for very large trees due to lack of data (Calders et al., 2014).
  - Private domains often excluded (Davies et al., 2011)
- Remote Sensing

Carbon Flows

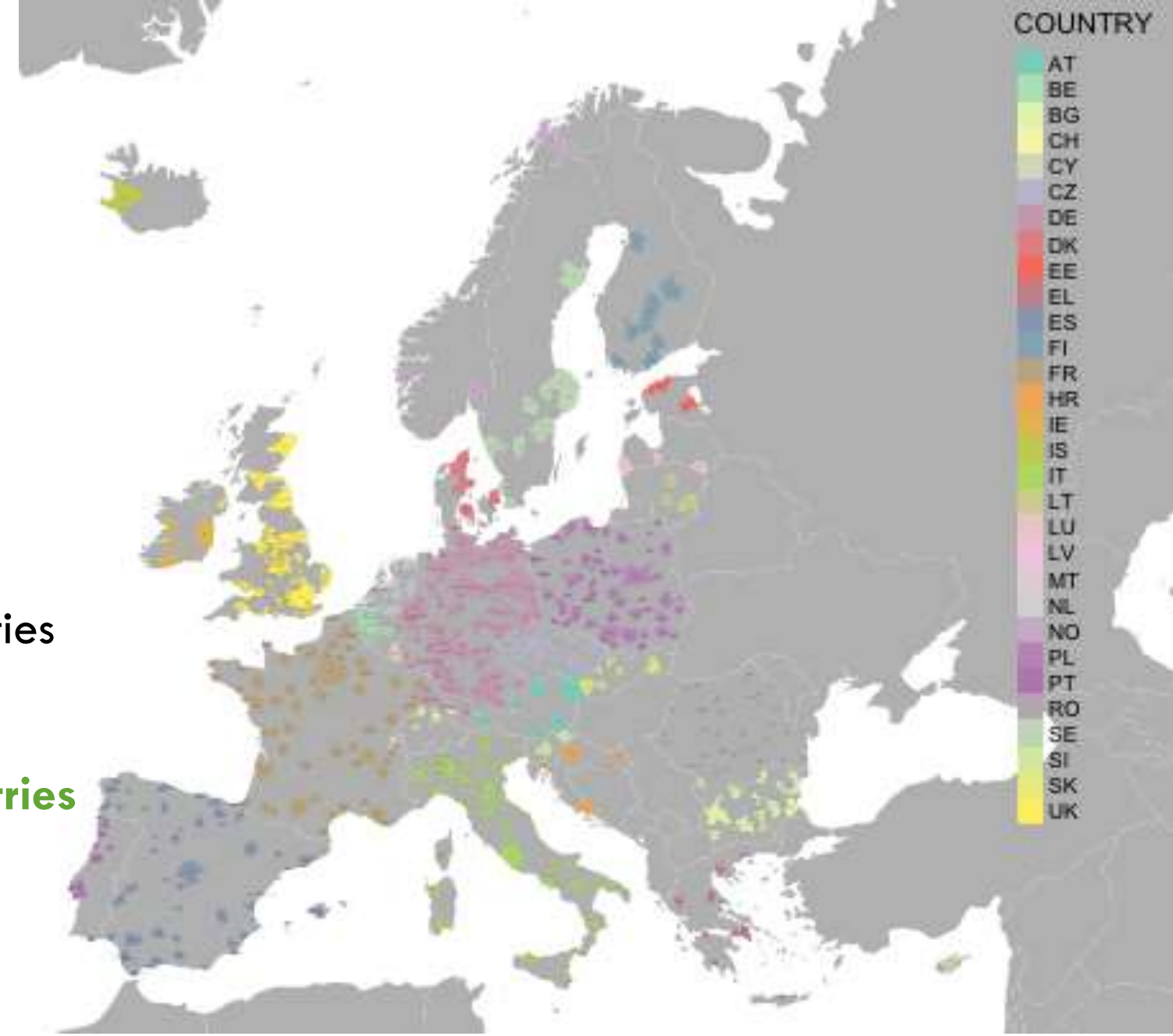
- Eddy Covariance - micrometeorology (Kotthaus and Grimmond, 2012 - Massman and Lee, 2002 – Burda, 2013)
  - Urban climatology seeks to understand “how, and by how much, [the climate] has been changed from its 'natural' state". (Oke, 1984)
- Urban Carbon Metabolisms (Kellett et al., 2013)
  - Take into account the built-up, vehicles, humans, vegetation and soils
  - Require a large amount of data
  - Allow to assess scenarii and their impacts

DATA

- GMES/Copernicus Urban Atlas 2012: 693 cities in 31 countries
- Layer STL 2012: 293 cities
- Layer Population 2012: 303 cities

Match for 174 cities in 17 countries

"Cities" corresponding to FUAs – Functional Urban Areas



METHODOLOGICAL PROPOSAL

Carbon Sources

- Buildings: b_{ijt}
- Vehicles: v_{ijt}
- Humans: h_{ijt}
- Urban Forest: f_{ijt}

Carbon Sinks

- Street Trees: t_{ijt}
- Green Areas: g_{ijt}

Disaggregated Model

Emissions

$$e_{ijt} = b_{ijt} + v_{ijt} + h_{ijt} + f_{ijt}$$

Uptake

$$s_{ijt} = t_{ijt} + g_{ijt}$$

METHODOLOGICAL PROPOSAL

Notion of Diffusion

Horizontal air flows

Atomic elements are moved in the air due to atmospheric conditions such as wind intensity and direction, humidity rate or air temperature

How CO2 are spread across space in a given time slot?

Spatial weighted moving averages

Notion of Ascension

Vertical air flows

Which atmospheric layer of study?

From which distance are we considered out of the city system?

METHODOLOGICAL PROPOSAL

Diffusion and Ascension

Function of wind speed, wind direction, air temperature, pressure and humidity,…

Disaggregated Model bis

Emissions

$E_{ijt}\ (e_{ijt} + diff_{ijt} + asc_{ijt})$

Uptake

$S_{ijt}\ (s_{ijt} + diff_{ijt} + asc_{ijt})$

THANK YOU FOR YOUR ATTENTION

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CASE STUDY *LEICESTER*

(DAVIES ET AL., 2011)

Estimating the storage capacity of the city

231 521 tC in the aboveground biomass (AGB)

97.3% of the carbon sink related to trees

Methodology: Allometric Equations

✓ Requires field data (dimensions) or remote sensing data,

✓ Public and private domains

CARBON BUDGET *2006-2015*

Global anthropogenic CO_2 flows

Atmospheric Variation

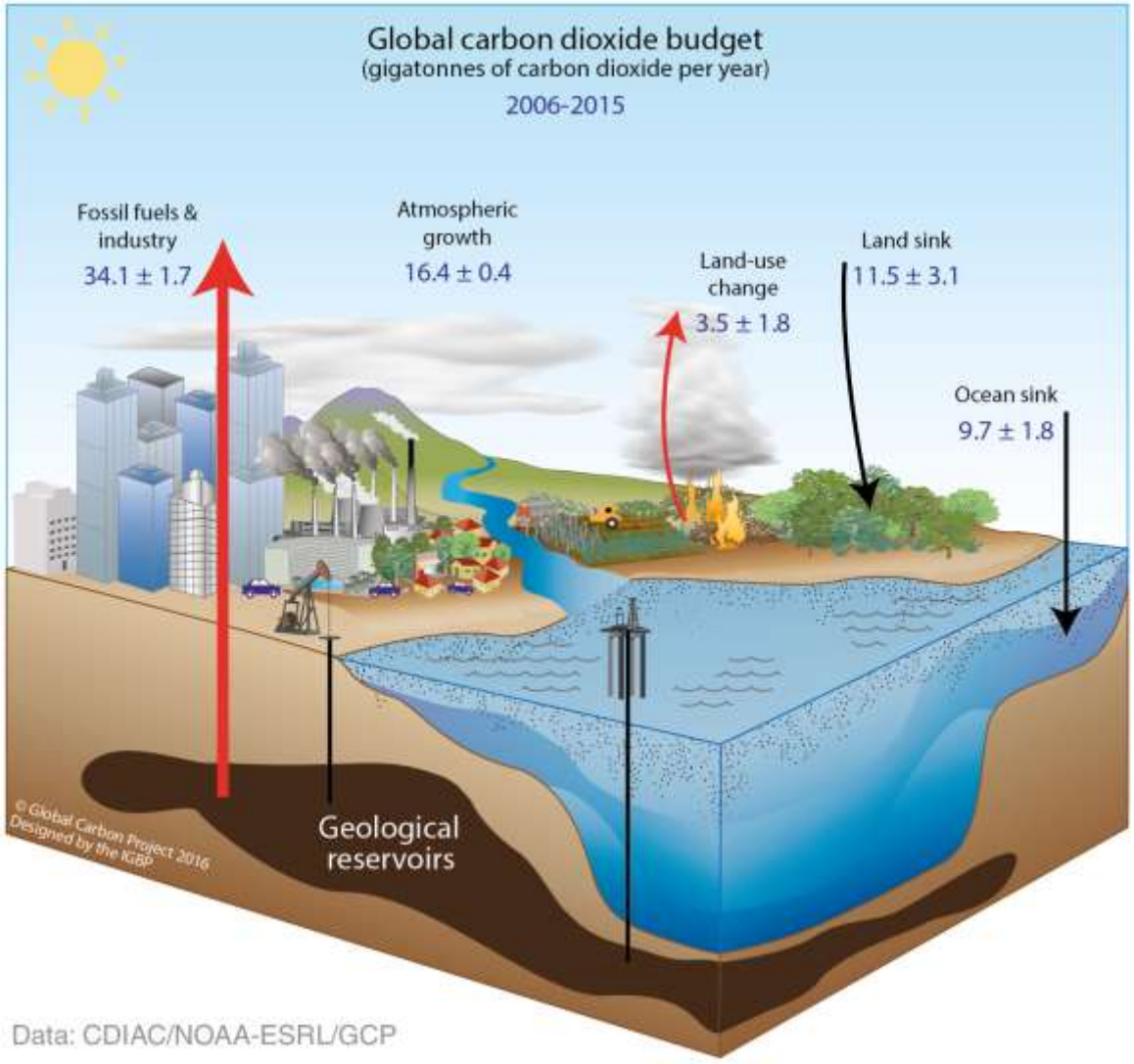
+16,4 Gt CO2 per year

+ 44,9 billions of kg per day

How to offset these emissions?

Convert 55.7% of the emerged areas on Earth into tempered forests? (assumed to uptake ≈ 540 kg CO_2 / day), corresponding to:

Europe + North, Central and South Americas + Africa (≈ 83 millions of km^2)



CASE STUDY *VANCOUVER*

(KELLETT ET AL., 2013)

Analyse des flux: Quartier *Sunset*

Prend en compte : le bâti, les véhicules, les personnes, la végétation et les sols

Nécessite des données spatiales et non spatiales : cadastres, statistiques nationales et remote sensing

Permet d'évaluer différents scénarios d'aménagement urbains et leurs impacts