METROPOLE: An Integrated Framework to Analyze Local Decision Making and Adaptive Capacity to Large-Scale Environmental Change
Community Case Studies in Brazil, UK and the US

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The hypothesis of the METROPOLE Project is that the understanding and perception of risks associated with climate change are best assimilated when co-produced with scientific basis allied to a social, political and cultural context, and with a strong participation of local communities on decision making.

With a strong applicative component, the study was developed in three coastal areas, each one representing one of the three countries involved: City of Santos, São Paulo (Brazil), Selsey/Chichester, West Sussex (United Kingdom) and Broward County, Florida (United States).

Santos is a big industrial city, and home to the largest port on South America’s Atlantic Coast.
Total area 281 km²

Continental area 241,6 km²

Insular area 39,4 km²

Population 419,4 mil (IBGE 2010)

0,7% in Continental area
99,3% in Insular area

Municipality of Santos / São Paulo / Brazil
Why Santos?

- Regional leader in sustentability, environmental issues and economical development
- Strong local governance and community participation on government decisions
- Coastal Vulnerability on short and long term
- Largest port in Brazil, tourism and freight

Storm surge due to a high tide episode in September 2009, that affected the Ponta da Praia region and disturbed circulation along the main avenue

Erosion in the Ponta da Praia region of Santos (SE) due to a dangerous storm surge episode in April 2013
Two regions of Santos were selected: NW (Northwest) and SE (Southeast) for SLR and associated impacts

- Different land use patterns and occupation (different vulnerabilities) and property values (SE-Ponta da Praia, more expensive than NW)
- Under hydrometeorological risks: storm surge, high tides, intense rainfall and strong winds
- Why 2 regions only: cost and time limitations in data processing and obtaining parameters needed to run COAST model
Model to estimate SLR and economic damages due to SLR in Santos: COAST model

- **COAST (Coastal Adaptation to Sea Level Rise Tool)**
  - COAST was developed by Catalysis Adaptation Partnership collaboration of University of Maine and Southern Florida
  - Modeling of floods and economical damages and property lossess due to strom waves and floods due SLR
  - Visualization tool showing flooding patterns and accumulated damages in buildings and properties due to floods for 2050 and 2100 for 1 in 100 year storm
  - Cost/benefit estimated with and without adaptation measures
  - It does not take into account beach and shoreline erosion, the regression of the costal within time, the effects caused to services and urban infrastructure, as well as the resilience of natural systems, and potential changes in local circulation, salinity etc. that may affect local SL.
**Geospatial geo-referenced data:**
Digital Elevation Models (DEMs) from LiDAR;

**Sea Level Rise data:**
Subsidence, observed elevation of mean high tide, extreme tides and surge height; Flood Maps

**Socio-economic data:**
Location of Buildings; digital tax parcel map; Value and tax assessment values of buildings; Depth Damage Function

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**NO-ACTION SCENARIO**

Northwest and Southeast regions, for no-adaptation and adaptation scenarios:
Building damage we might expect from one-time future events; Cumulative damage from many different sized storms; Parcels of land we might lose to SLR; Assessments of structural damages to buildings due to storm surge and SLR

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**COAST Platform**

COAST run for a 100 year storm
Vulnerability assessment (no-adaptation or no-action)

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DATA NEEDED

COAST RUN UNDER TWO SCENARIOS
SLR scenarios-No action: SE Zone

2050 (0.18 m + 1.60 m)  2050 (0.23 m + 1.60 m)  2050 (IPCC: 0.30 m + 1.60 m)

2100 (0.36 m + 1.66 m)  2100 (0.45 m + 1.66 m)  2100 (IPCC: 1.0 m + 1.66 m)
Damages scenario-No action: SE zone

2050 (0.18 m + 1.60 m)  
2050 (0.23 m + 1.60 m)  
2050 (IPCC: 0.30 m + 1.60 m)  

2100 (0.36 m + 1.66 m)  
2100 (0.45 m + 1.66 m)  
2100 (IPCC: 1.0 m + 1.66 m)  

Note: The images depict the extent of damages in the SE zone under different sea level rise scenarios.
**Geospatial geo-referenced data:**
Digital Elevation Models (DEMs) from LiDAR; Sea Level Rise data:
Subsidence, observed elevation of mean high tide, extreme tides and surge height; Flood Maps

**Socio-economic data:**
Location of Buildings; digital tax parcel map; Value and tax assessment values of buildings; Depth Damage Function

**COAST Platform**
- COAST run for a 100 year storm
- Vulnerability assessment (no-adaptation or no-action)
- Benefit-cost analysis (with adaptation)

**Northwest and Southeast regions, for no-adaptation and adaptation scenarios:**
- Building damage we might expect from one-time future events; Cumulative damage from many different sized storms; Parcels of land we might lose to SLR; Assessments of structural damages to buildings due to storm surge and SLR

**NW zone:**
- dredging works, implementation of tide control gates in rivers and drainage canals (natural and artificial).
- Mangrove preservation, restoration, recuperation.

**SE Zone**
- Beach nourishment + dune restoration
- Structural enforcement and improvement of existing walls
- Water pumping in existent drainage canals and implantation
- Improvement of tide control gates.

The resulting benefit-cost ratios are then compared to identify the most robust strategy under a range of possible future SLR scenarios.
Adaptive measures proposed by population of Santos (participatory approach)

**NW zone:**

- Dredging works
- Mangrove preservation, restoration, recuperation
Adaptive measures proposed by population of Santos SE zone:

Water pumping in existent drainage canals and implantation improvement of tide control gates (not considered due to non available calculations for pumping systems)

Beach nourishment + dune restoration

(=Structural enforcement and improvement of existing walls
(elevation, relocation or buy outs were not chosen by the majority of the population)
BENEFIT (avoided damages) = Damages without adaptation - Damages with adaptation

COST: Cost of Adaptation measures

Benefit-cost ratio = BENEFIT/COST

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<thead>
<tr>
<th></th>
<th>Southeast Zone</th>
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<th>Northwest Zone</th>
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<tbody>
<tr>
<td></td>
<td>Low elevation</td>
<td>High elevation</td>
<td>Low elevation</td>
<td>High elevation</td>
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<td>Damages without adaptation actions</td>
<td>271’904,114</td>
<td>326’093,203</td>
<td>52’166,823</td>
<td>73’876,910</td>
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<td>Damages with adaptation actions</td>
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<td>Costs</td>
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<td>Cost-Benefit Rate</td>
<td>23.83</td>
<td>28.58</td>
<td>0.21</td>
<td>0.32</td>
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Storm surge August 21 2016
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