Spatial Analysis of Natural Hazard and Climate Change Risks in Peri-Urban Expansion Areas of Dakar, Senegal

URBAN WEEK 2009
BBL
Preston Lounge
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• Content

1) Conceptual study framework

2) Natural & climate change related hazards

3) Map generation

4) Spatial analysis

5) Conclusion
Where are the people moving to?

What is the value of land affected by natural hazards?

Which areas are at risk?

How much safe building land is available?
• Background

- Massive rural-urban migration flow into Greater Dakar, due to deteriorating climate and soil conditions for agriculture
- Rapid population growth leading to uncontrolled peri-urban expansion & heavy pressure on peri-urban areas
- High proportion of new urban settlements is on sites at risk due to natural and climate change related hazards
- Need for better preparedness in managing urban expansion - strengthening resilience of local urban authorities
• Project objectives

*Spatial Analysis of Natural Hazard and Climate Change Risks*

– Develop a **generic methodology supporting urban growth analysis** related to natural hazards and climate change risks

  • Monitoring Peri-urban expansion

  • Risk diagnostics

– Enable comparison of **peri-urban expansion areas** of major cities on a continental level

– Establish **a geographic information base** employing time-series satellite, socio-economic and other geospatial data
PERI-urban expansion
P1, 01/19/2009
• **Study scope & limitations**
  
  – **Generic study concept addresses all pertinent hazards for Dakar**
    
    *Limitation:* for spatial analysis only selected hazards are considered (flooding, coastal erosion, sea level rise)
  
  – **Approach at an intermediate scale can be applied to any other city at reasonable costs (given respective input data)**
    
    *Limitation:* Consideration of local phenomena (e.g. ground subsidence) requires local expertise as well as additional input data and analysis
  
  – **Estimation of the spatial distribution of relative hazard potentials**
    
    *Limitation:* no absolute damage-frequency relationships & probabilities and their spatial differentiation can be derived
  
  – **Focus is on exposure-related information**
    
    *Limitation:* vulnerability is only approximated by spatial indicators and inferred from hot-spots of exposure
  
  – **Social & economic exposure/vulnerability as key topics**
    
    *Limitation:* no information on ecologic & institutional vulnerability and resilience (e.g. protection measures by local authorities) is provided
• Conceptual study framework

Definition of “risk” by the UNDP, 2004:
“The probability of harmful consequences … resulting from interactions between natural or human induced hazards and vulnerable condition.”

Source: Thywissen 2006

Risk as a function of
- Hazard (=potentially damaging event)
- Vulnerability (=susceptibility of a community)
- Exposure (=quantity of exposed elements)
- Resilience (=strategies for relief and recovery)
• Natural and Climate Change related Hazards in Dakar
  Drivers: natural setting / migration / climate change / …

  ![Drought](image)

  ![Flooding](image)

  ![Sea level rise](image)

  ![Coastal erosion](image)
3 Map Generation

Detailed Thematic Landuse Map of Dakar 2008

Geospatial information on urban extent and land uses

Legend
- Central business district, very dense urban fabric 80-100%
- Mixed use, dense urban fabric 50-79%
- Immensely residential, low to medium density urban fabric 10-49%
- Suburbanized rural areas
- Industrial/commercial areas
- Roads (asphalted roads > 10m width)
- Railways
- Port areas & Airports
- Mineral extraction sites
- Greenbelt areas & other non-built-up urban areas
- Forests
- Water
- Agricultural areas and other open non-urban land

Transverse Mercator Projection

Produced by GeoVille Group for World Bank under contract number: 7148548 in November 2008
Remark: Mapping of roads if covered with asphalt and width larger than 10m
Geospatial information on urban expansion and land use changes

Legend
- Residential areas
- Non-residential urban areas
- Transport units
- Green urban areas & other non-built-up urban areas
- Forest
- Water
- Agricultural areas and other open non-urban land

Transverse Mercator Projection

Produced by GeoVille Group for World Bank under contract number: 7148548 in November 2008
3 Map Generation

- Geospatial mapping of the different hazards

### Relative Flood Potential of Dakar

#### Legend:
- High Potential
- Moderate Potential
- Low Potential
- No Potential
- Permanent Water Bodies
- Build Up Areas
- Road Network

### Coastal Erosion Potential of Dakar

#### Legend:
- High Potential
- Moderate Potential
- Low Potential
- No Potential
- Permanent Water Bodies
- Build Up Areas
- Road Network

### 1 m Coastal Inundation Potential of Dakar

#### Legend:
- No Potential
- Low Potential
- Moderate Potential
- High Potential
- Build Up Areas
- Road Network

### 5 m Coastal Inundation Potential of Dakar

#### Legend:
- No Potential
- Low Potential
- Moderate Potential
- High Potential
- Build Up Areas
- Road Network

Transverse Mercator Projection

Produced by GeoVille Group for World Bank under contract number: 7148548 in January 2009
Geospatial mapping of multiple hazards
- Relative Flood Potential (RFP)
- Coastal Erosion Potential (CEP)
- Coastal Inundation Potential (CIP)
Comparison of census-based and spatially disaggregated population distribution

- Population per department statistics
- Disaggregated population density per 250m Grid cell (2008)
• 3 dimensional population on grid level
## Dakar – Land use change statistics 1988-2008

<table>
<thead>
<tr>
<th>Thematic classes</th>
<th>1988</th>
<th>2008</th>
<th>Change in km²</th>
<th>Change in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential areas</td>
<td>81.58</td>
<td>102.04</td>
<td>+ 20.46</td>
<td>+ 25.1</td>
</tr>
<tr>
<td>Non residential urban areas *</td>
<td>29.91</td>
<td>38.07</td>
<td>+ 8.16</td>
<td>+ 27.3</td>
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<tr>
<td>Transport units</td>
<td>15.17</td>
<td>15.49</td>
<td>+ 0.32</td>
<td>+ 2.2</td>
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<tr>
<td>Green &amp; other non-built-up urban areas</td>
<td>73.16</td>
<td>47.87</td>
<td>- 25.29</td>
<td>- 34.6</td>
</tr>
<tr>
<td>Forests</td>
<td>15.98</td>
<td>15.99</td>
<td>+ 0.1</td>
<td>+ 0.1</td>
</tr>
<tr>
<td>Water</td>
<td>4.88</td>
<td>6.37</td>
<td>+ 1.49</td>
<td>+ 30.6</td>
</tr>
<tr>
<td>Agricultural and other open non-urban land</td>
<td>362.22</td>
<td>356.13</td>
<td>- 6.09</td>
<td>- 1.7</td>
</tr>
</tbody>
</table>

* Comprises all industrial / commercial areas incl. water supply infrastructure, construction & mineral extraction sites.
• **Rate of Urban Development in Dakar’s Metropolitan Area**

**Development of Built-up area 1988-2008**

- 1988: +10.0%
- 1999: +10.4%
- 2008: +12.2%
- 1988: +12.4%
- 1999: +9.6%
- 2008: +14.3%

**Share of built-up area 1988-2008**

- **Urban communes**: 23% of total area built-up, 77% of total area non-built-up
- **Peri-urban communes**: 45% of total area built-up, 55% of total area non-built-up
- **Rural communes**: 94% of total area built-up, 6% of total area non-built-up

► 77% of the land in Greater Dakar’s urban communes are built-up

► The built-up area in Dakar’s peri-urban and rural communes increases with a growth rate of >1% p.a.
Rate of population growth (+74%) is significantly higher than urban area expansion (+23%)
• Population Growth & Social Vulnerability

**4 Spatial analysis**

**Peri-Urban Areas 1988 - 2008:**

40% of the „newcommers“ have settled in areas with significant hazard potential
• Potential expansion areas exposed to risk

- 17% of the open land in Dakar’s peri-urban communes is exposed to high risk
4 Spatial analysis

• Land Price Values & Economic Vulnerability

The Dakar Metropolitan region represents a total land value of 44 billion USD. 4,9% of this land value, i.e. 2.15 billion USD, are at high risk.

Land price values exposed to high risk in Mio USD. All land price values are based on estimations provided by World Bank Country Office in Senegal.
• Land Price Values & Economic Vulnerability

- Coastal Erosion Potential
- Coastal Inundation Potential
- Relative Flood Potential

- Urban areas most affected - $1.030 billion USD

Rural areas most affected - $1.030 billion USD
Next step

Formulating policy recommendations with local experts

How much safe building land is available?

Where are the people moving to?

What is the value of land affected by natural hazards?

Which areas are at risk?
• Generic concept for peri-urban monitoring & risk diagnostics - applicable for other African cities

• Validated, modular and expandable information base for better management & planning of future expansion

• Spatial dimension makes trends visible "at-a-glance". This can assist effective policy formulation, leading to
  – improving preparedness of local urban authorities
  – strengthening the resilience of local communities
Thank you for your attention

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