Potential Climate Change impacts in Hyderabad/India

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Research conducted under
CLIMATE AND ENERGY IN A COMPLEX TRANSITION PROCESS TOWARDS SUSTAINABLE HYDERABAD
MITIGATION AND ADAPTATION STRATEGIES BY CHANGING INSTITUTIONS, GOVERNANCE STRUCTURES, LIFESTYLES AND CONSUMPTION PATTERNS
Hyderabad/India: location

Dr. Matthias Lüdeke
• From Climate Change (CC) to it’s impacts on urban functions
  - modelling
    input 1: scenarios for socio-economic variables
    input 2: changed climate variables
  
  output: expected effects/damages

• From expected impacts to adaptive city planning
  - checking development plans against expected CC impacts
  - choosing more CC-adapted development options
Hyderabad: disparities

HITEC city, Hyderabad

Old City, Hyderabad

Slum area, Hyderabad
Trend in slum development

### Households by Standard of Living Index in Hyderabad

<table>
<thead>
<tr>
<th>Standard of Living Index</th>
<th>DLHS-2 (2002-04)</th>
<th>DLHS-3 (2007-08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>2.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Medium</td>
<td>25.8</td>
<td>17.3</td>
</tr>
<tr>
<td>High</td>
<td>71.7</td>
<td>76.0</td>
</tr>
</tbody>
</table>

Values in % of the actual population. District level household survey, IIPS
Climate Change projections and their certainty for Hyderabad

Main Methodological Elements:

--> two global CO2-emission scenarios, describing a high and low emission future:  
   A2: business as usual and  
   B1: global emission reduction from about 2035 on

--> model runs of 17 global circulation models using the above emission scenarios (done for IPCC, AR4)

--> downscaling of global model runs for the Hyderabad area

--> degree of certainty is assessed by consensus amongst the model runs

--> weighting: ability of a model to reproduce the present climate is considered in final projection results
Climate Change projections and their certainty for Hyderabad

Results 1: Extreme Events

Change in Number of Days/Year with Precip. > 80mm [%]

Number of Heat Wave Days/Year

Colored boxes; range covered by about 70% (±σ-range) of the weighted models, for the respective timeslice and global emission scenario. Lines: range covered by outliers
Pluvial flooding: assessing impacts under poor data availability and uncertainty

50% impact reduction under the Low Emission scenario
Vulnerability towards pluvial flooding

Lacunarity based slum identification from actual QuickBird (0.6x0.6m) satellite imagery

Kit et al., 2011

SRTM-based water flow under heavy rain (80mm/d) events: $10^4$mm/s

Flood prone slum areas

Flooded non-slum area

Save slum areas

August 2000 – flood: about 80 slums areas completely washed away

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Heat waves & local heat islands

Empirically based hypotheses for adaptive city planning, rich relations to mechanistic urban climate modelling

present location and structure of hot and "cool" spots

T - Minima & Maxima of all heat wave days

Polakowski et al., 2012
Traffic interruptions by flooding

Modeled urban traffic flows together with the flow accumulation maps allow for the identification of future hotspots of traffic interruptions caused by climate change.

24 Hour Vehicle Volume (Model Result 2011)
- Under 25,000 Veh/day
- Under 50,000 Veh/day
- Under 75,000 Veh/day
- 75,000 Veh/day and more

Schäfer et al., PTV, 2011
Hyderabad

Heat waves:
- Combination of remote sensing and mechanistic urban climate modelling (CCLM-DCEP)
- Impacts on health

Pluvial floods:
- Role of (traditional) tanks in the larger urban area for flood damage avoidance

Spatial slum development:
- RS-based trends & scenarios

Large urban agglomerations in developing countries

- Application of the new urban RS-techniques on a larger set of cities
- Identification of structural properties determining urban CC-vulnerability
Thank you
SLI-Definition

Source of drinking water:  
3 for Tap (own), 2 for Tap (shared), 1 for hand pump and well, and 0 for other;

Type of house:  
4 for pucca, 2 for semi-pucca, and 0 for kachcha;

Source of lighting:  
2 for electricity, 1 for kerosene, and 0 for other;

Fuel for cooking:  
2 for LPG gas/electricity, 1 for kerosene and 0 for other;

Toilet facility:  
4 for own flush toilet, 2 for own pit toilet, 2 for shared toilet and 0 for no toilet;

Ownership of durables:  
4 each for car and tractor, 3 each for television, telephone and motorcycle/ scooter, and 2 each for fan, radio/transistor, sewing machine and bicycle.

The scores when totaled may vary from a lowest of 0 to a maximum of 40.  
On the basis of total score, households are divided into three categories:

a) Low – if the total score is less than or equal to 9,
b) Medium – if the total score is greater than 9 but less than or equal to 19 and 
c) High – if the total score is greater than 19.

From:
Reproductive and Child Health District Level Household Survey (DLHS-2) 2002-04 India
H: mainstream planners viewpoint

Indischer Inselurbanismus

archplus 185
Climate Change projections and their certainty for Hyderabad

Results 2: Annual Means

Mean Annual Temperature [°C]

Annual Precipitation Sum [mm]
Red areas: additional flood-affected areas: 2100, high population (exp.) and emission (A2) scenario
Ward-wise additionally affected slum population: NW highly endangered 2070, low population (lin.) and high emission scenario (A2)
Red areas: additional flood-affected areas -> targeted adaption measures 2100, high population (exp.) and emission (A2) scenario
High priority CC-induced traffic interruptions -> adaptation by traffic planning and road construction measures: 2040, low emission scenario (B1)
How to introduce climate change knowledge into the city planning process

- CC – adapted planning demands for the integration of information from various – often **spatially distributed - actors** (municipal cooperations, HMWSSB, different departments of HMDA, …)

Relevant actions of **these distributed actors**:
- retrieving comprehensive spatial information to improve planning decisions
- adding new spatial information to the existing stock to guarantee its consideration in the planning process
- making selected spatial information accessible for the public

-> this is realized best by using a **Web-GIS** (clients only use their web-browser; server should be at HMDA)
Example: Model-Based Impact Analysis

- Reduction of road capacity at flood locations (different scenarios e.g. 30%, 50% residual cap.)

- New assignment of traffic on modified network (with-case)

- Calculation of parameters or indicators for case 1.) without flooding and 2.) with flooding based on model-results
### Example: First Results of location-fine Impact Analysis

<table>
<thead>
<tr>
<th>Indicator</th>
<th>[Unit/a]</th>
<th>Result R4_R5 - 50%-capacity</th>
<th>Result B1 - 50%-capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of event per year</td>
<td>days</td>
<td>0.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Cutoff crucial civic infrastructure (Hospitals, Fire Brigade)</td>
<td>semi-qualitative</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Affected sensitive areas (Residential etc.)</td>
<td>semi-qualitative</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Affected shops, offices etc.</td>
<td>semi-qualitative</td>
<td>in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>Affected street vendors</td>
<td>semi-qualitative</td>
<td>in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>Affected pedestrians and cyclists</td>
<td>semi-qualitative</td>
<td>in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>Affected PuT lines (Bus + MMTS + MRTS)</td>
<td>semi-qualitative</td>
<td>in progress</td>
<td>in progress</td>
</tr>
<tr>
<td>Additional travel time</td>
<td>P-hrs</td>
<td>43.680</td>
<td>114.130</td>
</tr>
<tr>
<td>Additional fuel consumption</td>
<td>g fuel</td>
<td>2.925.320</td>
<td>4.375.493</td>
</tr>
<tr>
<td>Additional CO₂-emissions</td>
<td>g CO₂</td>
<td>8.208.171</td>
<td>12.319.758</td>
</tr>
<tr>
<td>Additional NOx-emissions</td>
<td>g NOx</td>
<td>24.695</td>
<td>51.709</td>
</tr>
<tr>
<td>Additional PM-emissions</td>
<td>g PM</td>
<td>808</td>
<td>1.057</td>
</tr>
<tr>
<td>Additional vehicle operation costs</td>
<td>INR</td>
<td>229.652</td>
<td>155.589</td>
</tr>
</tbody>
</table>