An Urban Model for Analyzing Thermal Effects Dependent on Spatial Parameters

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Content

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• Methodology
  - Spatial dimension
  - Temporal simulations
  - Specific research areas
• Research framework
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• Q & A
Research Question

How can we plan the land use in a more sustainable way under the concern of temperature and energy consumption?

• City landscape structures & temperature change
• Optimal urban land use pattern
• Surface & layout changes
• A simulation tool
L-E-T Model
Methodology

Spatial

Temporal

Specific place

LET Correlation

Introduction/Methodology/Framework/Results

Spatial dimension

L-E correlation

- SEA (Strategic environmental assessment) (L. White et al. 2013)
- Top-down approach (S. Mohammandi et al. 2013, L.G. Swan 2009)
- Bottom-up approach (S. Mohammandi et al. 2013, L.G. Swan 2009)
- Analytical framework (J.G. et al. 2013)

L-E-T correlation

- Prediction method: engineering, statistical, neural network, support vector machine, grey models (H. Zhao et al. 2012)
- Systematic review methodology (D. E. Bowler 2010)
- Compare countries difference (L. Pérez-Lombard et al. 2008)
- SWOT, land-use models (C. Agarwal et al. 2002)
Temporal simulations

L-T correlation

- KNMI’06 Scenarios (KNMI 2009)
- W/ W+ scenarios (KNMI 2009)
- G/ W scenarios (KNMI 2009)

E-T correlation

- Global climate models (GCMS) (KNMI 2006)
- Regional climate model (RCMS) (KNMI 2006)
- Climate changes for Netherlnds (KNMI 2006)
Temporal simulations

L-E-T correlation

- Scenarios to predict future weather (KNMI’14)
- Regional climate model RACMO2 (B,D.V. Hurk et al. 2014)
- EC-Earth model (B,D.V. Hurk et al. 2014)
- Climate Explorer of KMNI (B,D.V. Hurk et al. 2014)
- EU environmental policies review (National Institute for Public Health and the Environment, Netherlands. 2004)
Specific research area

L-E correlation

- Urban Planning System (M. Wolsink et al. 2003)
- Sustainable urban form and energy demand (M. Wolsink et al. 2003)
- Knowledge of local conditions (M. Wolsink et al. 2003)
### Specific research area

- **E-T correlation**

<table>
<thead>
<tr>
<th>Method/Framework/Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-T correlation</td>
</tr>
</tbody>
</table>

- **Land use inventory** *(W. Leduc et al. 2013)*
- **Energy demand inventory** *(W. Leduc et al. 2013)*
- **Local renewable/residual energy potential analysis** *(W. Leduc et al. 2013)*
- **Clusters of spatial functions exploration** *(W. Leduc et al. 2013)*
- **Energetic linkages analysis** *(W. Leduc et al. 2013)*
- **Network patterns exploration** *(W. Leduc et al. 2013)*
Specific research area

**L-T correlation**

- Regression analysis for nocturnal UHI (B.G. Heusinkveld et al. 2014)
- Relation between UHI and open water fraction (G.J. Steeneveld et al. 2014)
- Building types and energy consumption (B. Howard et al. 2012)
- Linear regression of UHI max and inhabitants number (L.W.A. van Hove et al. 2011)
- Cell analysis of urban morphology on temperature (S. J. Janssen et al. 2011)
Specific research area

- Spatial relationship of neighboring land uses and local temperature (J. Kim et al. 2013)
- Data collection from Cargo bike to model the urban climate (B. V. Hove et al. 2011)
- Model the impact of land use and climate change (L.A. House-Peter et al. 2011)
LET correlations methods

- **Method**
  - Statistical analysis
  - Engineering
  - Neural network

- **Spatial Scale**
  - Country
  - City
  - Neighbor
  - Zip code
  - Census block
  - Author defined

- **Variables**
  - Dependent variables
  - Independent variables

- **Land use change**
  - Sprawl scenario
  - Dense scenario
Research Framework

- Land (L) use map
- Energy (E) consumption map
- Temperature (T) map
- Spatial interaction parameters
- L-E-T interaction model
- L-E-T correlation
- Land (L) use change forecast
- Energy (E) consumption forecast
- Temperature (T) change forecast
- Spatial transition scenarios
L-E-T Model

- Land (L) Use Map
- Energy (E) Consumption Map
- Temperature (T) Map

Past  | Now  | Future
Research Area

Rotterdam: 51°55’51”N, 4°28”45’E
Zip code: 3011, 3012
Land use & Energy & Temperature

Land use (L): DANS (Data Archiving Networked Services)
Energy Consumption (E): City of Rotterdam
Temperature (T): Landsat-USGS
### Land Use

<table>
<thead>
<tr>
<th>Coding group</th>
<th>Coding</th>
<th>Land use type</th>
<th>Coding group</th>
<th>Coding</th>
<th>Land use type</th>
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<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>Rail area</td>
<td>5</td>
<td>50</td>
<td>Greenhouse cultivation</td>
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<tr>
<td></td>
<td>11</td>
<td>Road area</td>
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<td>51</td>
<td>Other agricultural area</td>
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<tr>
<td></td>
<td>12</td>
<td>Airport</td>
<td>6</td>
<td>60</td>
<td>Forest</td>
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<tr>
<td>2</td>
<td>20</td>
<td>Residential area</td>
<td>61</td>
<td></td>
<td>Natural area,</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Retail and bars</td>
<td>62</td>
<td></td>
<td>Natural area,</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Public facilities</td>
<td>7</td>
<td>70</td>
<td>Ijsselmeer</td>
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<tr>
<td></td>
<td>23</td>
<td>Social &amp; cultural</td>
<td>71</td>
<td></td>
<td>Closed sea</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Industrial areas</td>
<td>72</td>
<td></td>
<td>Rijn &amp; Maas</td>
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<tr>
<td></td>
<td>30</td>
<td>Dump</td>
<td>73</td>
<td></td>
<td>Border lake</td>
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<tr>
<td></td>
<td>31</td>
<td>Wreck/storage place</td>
<td>74</td>
<td></td>
<td>Water winning</td>
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<tr>
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<td>32</td>
<td>Cemetery</td>
<td>75</td>
<td></td>
<td>Water area leisure</td>
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<tr>
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<td>33</td>
<td>Mineral production place</td>
<td>76</td>
<td></td>
<td>Enclosed water mineral production</td>
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<tr>
<td></td>
<td>34</td>
<td>Construction area</td>
<td>77</td>
<td></td>
<td>Overflow area</td>
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<td>35</td>
<td>Other open space</td>
<td>78</td>
<td></td>
<td>Other water</td>
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<tr>
<td>4</td>
<td>40</td>
<td>Park</td>
<td>8</td>
<td>80</td>
<td>Wadden sea, Dollard</td>
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<td></td>
<td>41</td>
<td>Sport</td>
<td>81</td>
<td></td>
<td>Oosterschelde</td>
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<tr>
<td></td>
<td>42</td>
<td>Community garden</td>
<td>82</td>
<td></td>
<td>Westerschelde</td>
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<tr>
<td></td>
<td>43</td>
<td>Leisure (short stay)</td>
<td>83</td>
<td></td>
<td>North sea</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>Leisure (long stay)</td>
<td>9</td>
<td>90</td>
<td>Foreign country</td>
</tr>
</tbody>
</table>
Land Use

- Residential: 40%
- Retail: 37%
- Industrial: 8%
- Water: 9%
- Road: 4%
- Social: 1%
- Public: 1%

Introduction/Methodology/Framework/Results
FME (File Management Engine)

Cell size: 50*50 m²
Selected Area: 25,075 m²
**FME to Excel - Land Use**

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**Introduction/Method/Framework/Results**

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**Table**:  
- Land Use values depicted in a grid with varying patterns.  
- Specific areas highlighted in green.  
- Numbers range from 0 to 20.  
- Some cells contain additional figures like 78 and 24.
Hypothetical Model

Difference between $R_1$ and $R_2$?
Algorithm

\[ y = \beta_1 x_1 + \beta_2 x_2 \]

- \( y \): natural logarithm of electricity consumption in central cell
- \( \beta_1 \): electricity consumption regression correlation of central land use
- \( \beta_2 \): electricity consumption regression correlation of neighboring land use
- \( x_1 \): land use % of central cell
- \( x_2 \): land use % of neighboring cell
**Algorithm-example**

\[ y = \beta_1 x_1 + \beta_2 x_2 \]

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Green</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>natural logarithm of electricity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_1 )</td>
<td>regression correlation of central cell</td>
<td>regression correlation of residential to residential</td>
<td></td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>regression correlation of neighboring cell</td>
<td></td>
<td>regression correlation of green to residential</td>
</tr>
<tr>
<td>( x_1 )</td>
<td>land use % of central cell</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>( x_2 )</td>
<td>land use % of neighboring cell</td>
<td>0</td>
<td>3/8</td>
</tr>
</tbody>
</table>

- G: Green
- W: Water
- R: Residential

![Table and Diagram](image-url)
Further steps
Thank You for Your Attention

Q & A

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