INTEGRATED LAND USE AND TRANSPORT PLANNING IN JEDDAH: POLICY ASSESSMENT AND SIMULATION

M. ALJOUFIE, M. ZUIDGEEST, M. BRUSSEL, M. VAN MAARSEVEEN

CODATU 2012: THE ROLE OF URBAN MOBILITY IN (RE)SHAPING CITIES
BACKGROUND
THE WORLD IS URBANIZING

- Currently, more than 56% of the world's population is residing in urban areas.
- Cities, world wide, face a challenge in managing their urban growth, land use and rapid motorization.
- In fast growing and developing cities like Jeddah, Saudi Arabia this is particularly the case.
URBANIZATION AND TRANSPORT

Migrants

Urban sprawl, congestion, pollution

Urban-region interactions

UNIVERSITY OF TWENTE.
Land use and transport are strongly related:

- Fast growing population, space use and motorization cause significant increases in congestion and its related negative effects:
  - *Environmental pollution, economic losses due to congestion*

- The transport system influences patterns of growth as well as the potential of economic opportunity through the accessibility it provides to land and activities:
  - *Social exclusion, urban sprawl*
Understanding the mutual interaction between the land use and transport systems is crucial for urban planners and transport planners.

Spatial and Temporal Interactions between Transport and Land use

Source: (Dantas and Ribeiro, 2006)
THE CITY OF JEDDAH, SAUDI ARABIA

- Jeddah is the second largest city in the Kingdom of Saudi Arabia.
Jeddah city started as a small fishing village within a wall.

After the discovery of oil in about 1938 and the destruction of the fortified wall of Jeddah in 1947 city Jeddah starting growing rapidly.
<table>
<thead>
<tr>
<th>Urban area (km$^2$)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.54</td>
<td>before 1947</td>
</tr>
<tr>
<td>2.8</td>
<td>1948</td>
</tr>
<tr>
<td>32.5</td>
<td>1958</td>
</tr>
<tr>
<td>56</td>
<td>1968</td>
</tr>
<tr>
<td>367</td>
<td>1986</td>
</tr>
<tr>
<td>1507</td>
<td>2007</td>
</tr>
</tbody>
</table>
- Reaching a population of more than 4 million today on an area of more than 1,500 sq. kilometres.
JEDDAH’S LAND USE CHANGES

Year


Area (ha)

0 5000 10000 15000 20000 25000

Residential Commercial Industrial Informal Settelment Public Places
TRANSPORT INFRASTRUCTURE EXPANSION

UNIVERSITY OF TWENTE.
• Urban spatial expansion (residential area growth) and transport infrastructure expansion in the city have gone hand-in-hand.
LAND USE – TRANSPORT ISSUES

- Yet, Jeddah has not been able to accommodate increases in travel demand, hence causing high levels of congestion.
LAND USE – TRANSPORT ISSUES

- In fact, the enormous spatial expansion combined with car-based transport policies (a/o’s fuel $0.61 per gallon, little investments in public transport) have caused large changes in travel behaviour since 1970.

- Car use: >93%, PT <3% in 2012
Over the last five decades, several master, structure and local plans have been prepared for Jeddah to control the urban change better: 1962, 1970, 1980, 1987, 1995 and 2005.

Notwithstanding the importance of these plans, the difficulty of matching urban growth, land use change and transportation have been underestimated, causing earlier mentioned issues and problems.

Conventional urban planning practices and lack of appropriate and coordinated policy are seen as the main issues.

Understanding the dynamics better is critical for Jeddah’s future.
A Cellular Automata (CA) is a regular grid of cells, where a neighbourhood is defined relative to a cell, and where the state of the neighbourhood determines the probability of transition of the cell at $t+1$.

CA have the capability to mimic the spatial and temporal processes of urban systems.

They allow to simulate and predict complex geographical phenomena.

Using the temporal datasets we built such model for Jeddah.
METRONAMICA LAND USE – TRANSPORT INTERACTION

www.metronamica.nl

Zoning

Land suitability

Accessibility

National / Regional spatial claims

CA-Spatial interaction model

Simple transportation model

Cellular Automata land use model

Production & Attraction

Distribution & Mode Choice

Route Assignment

Generalized Cost

Travel costs & Accessibility

Route choice & Allocation

Demand

Exogenous Land use

EXHIBITION
JEHDAAH METRONAMICA-LUTI
MODEL SET-UP

• Base year 1980
• 11 land use classes
• 5 land uses are dynamic (function class)

<table>
<thead>
<tr>
<th>code</th>
<th>Land use class</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Vacant</td>
<td>Vacant</td>
</tr>
<tr>
<td>1</td>
<td>Residential low density</td>
<td>Function</td>
</tr>
<tr>
<td>2</td>
<td>Residential medium density</td>
<td>Function</td>
</tr>
<tr>
<td>3</td>
<td>Residential high density</td>
<td>Function</td>
</tr>
<tr>
<td>4</td>
<td>Commercial</td>
<td>Function</td>
</tr>
<tr>
<td>5</td>
<td>Industrial</td>
<td>Function</td>
</tr>
<tr>
<td>6</td>
<td>Airport</td>
<td>Feature</td>
</tr>
<tr>
<td>7</td>
<td>Port</td>
<td>Feature</td>
</tr>
<tr>
<td>8</td>
<td>Public place</td>
<td>Feature</td>
</tr>
<tr>
<td>9</td>
<td>Green area</td>
<td>Feature</td>
</tr>
<tr>
<td>10</td>
<td>Informal settlement</td>
<td>Feature</td>
</tr>
<tr>
<td>11</td>
<td>Outside simulation</td>
<td>Feature</td>
</tr>
</tbody>
</table>
• 311 Traffic Analyses Zones (TAZ)
• 2 modes: car and public transportation
• 3 time periods (AM, PM, Rest of Day)
• 4 Trip purposes
  • Home-based work
  • Work – home
  • Work – work
  • Other
• Transport network of 1980 (4 road classes), incrementally expanded
• Base matrix of 1980 (initialization)
JEQUADH METRONAMICA-LUTI
MODEL SET-UP

- Validation: 2007 – 2011
- Prediction: 2011 – 2030
Land use change over time

Time Loop

Land use Interaction & weights

Zoning & Accessibility = Potential for change

Transition Rule

Cells change to land-use with highest potential until regional demands are met.

Land use at time T+1
Several workshops in Jeddah

Land use and transport policy scenarios:

1. Business As Usual (BAU)
2. Encouraging Public Transport (PT) – travel cost, car restraint etc
3. Transit Oriented Development (TOD) – strict zoning policies etc
4. Integrated Land use Transport Intervention (ILUT) – combined 2 + 3
LAND USE CHANGE
2011 - 2031

- Compact urban development scenarios will limit the ongoing urban expansion most

<table>
<thead>
<tr>
<th>Land use</th>
<th>2011</th>
<th>BAU 2031 change%</th>
<th>PT2031 change%</th>
<th>TOD2031 change%</th>
<th>ILUT2031 change%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacant</td>
<td>67930</td>
<td>-19.94</td>
<td>-19.91</td>
<td>-12.2</td>
<td>-12.1</td>
</tr>
<tr>
<td>Residential Low Density</td>
<td>12370</td>
<td>40.5</td>
<td>41.8</td>
<td>-13.6</td>
<td>-13.6</td>
</tr>
<tr>
<td>Residential Medium Density</td>
<td>7041</td>
<td>71.8</td>
<td>71.9</td>
<td>75.3</td>
<td>75.3</td>
</tr>
<tr>
<td>Residential High Density</td>
<td>3426</td>
<td>47.0</td>
<td>48.1</td>
<td>106.6</td>
<td>106.8</td>
</tr>
<tr>
<td>Commercial</td>
<td>3045</td>
<td>7.8</td>
<td>7.8</td>
<td>41.2</td>
<td>42.4</td>
</tr>
<tr>
<td>Industrial</td>
<td>7826</td>
<td>20.3</td>
<td>20.3</td>
<td>20.1</td>
<td>20.1</td>
</tr>
<tr>
<td>Airport</td>
<td>9629</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Port</td>
<td>760</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Public place</td>
<td>8172</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Green area</td>
<td>300</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Informal settlement</td>
<td>4395</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spatial expansion %</td>
<td>56964</td>
<td>23.7</td>
<td>24.0</td>
<td>14.5</td>
<td>14.6</td>
</tr>
</tbody>
</table>
TRANSPORT IMPACTS
2011 – 2031

• Sustainable transport scenarios seem to limit the increase in congestion most, while increasing the share of public transport

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2011</th>
<th>BAU 2031</th>
<th>Change</th>
<th>PT 2031</th>
<th>Change</th>
<th>TOD 2031</th>
<th>Change</th>
<th>ILUT 2031</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of trips</td>
<td>5,752,719</td>
<td>10,251,583</td>
<td>78.2</td>
<td>10,315,472</td>
<td>79.3</td>
<td>10,556,314</td>
<td>83.5</td>
<td>10,623,114</td>
<td>84.7</td>
</tr>
<tr>
<td>Car %</td>
<td>92.0</td>
<td>87.0</td>
<td>-5.4</td>
<td>69.7</td>
<td>-24.2</td>
<td>87.0</td>
<td>-5.4</td>
<td>69.0</td>
<td>-25.0</td>
</tr>
<tr>
<td>Public transport %</td>
<td>8.0</td>
<td>13.0</td>
<td>62.5</td>
<td>30.3</td>
<td>278.8</td>
<td>13.0</td>
<td>62.5</td>
<td>31.0</td>
<td>287.5</td>
</tr>
<tr>
<td>Average accessibility</td>
<td>0.57</td>
<td>0.47</td>
<td>-17.5</td>
<td>0.46</td>
<td>-19.3</td>
<td>0.56</td>
<td>-1.8</td>
<td>0.55</td>
<td>-3.5</td>
</tr>
<tr>
<td>Average trip distance car (km)</td>
<td>7.9</td>
<td>8.3</td>
<td>5.1</td>
<td>8.4</td>
<td>7.0</td>
<td>6.9</td>
<td>-12.1</td>
<td>7.1</td>
<td>-9.6</td>
</tr>
<tr>
<td>Average trip duration car (min.)</td>
<td>37.8</td>
<td>44.4</td>
<td>17.5</td>
<td>40.4</td>
<td>6.9</td>
<td>48.7</td>
<td>28.8</td>
<td>38.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Daily Congestion (km)</td>
<td>556.0</td>
<td>825.0</td>
<td>24.0</td>
<td>723.0</td>
<td>30.0</td>
<td>690.0</td>
<td>24.1</td>
<td>627.0</td>
<td>12.8</td>
</tr>
</tbody>
</table>
CONCLUSION AND FURTHER RESEARCH

- Fast growing urban areas such as Jeddah face enormous challenges managing land use, transport and its impacts.
- A dynamic land-use transport interaction model, such as the CA based version of this model used here, allows to simulate and predict the complex interaction between urban change and transport, and assist to reshape cities.
- The developed model shows that even for a car-dominated city such as Jeddah an integrated land use – transport strategy favouring both compact development and public transport investment can reduce urban sprawl and car-dependency.
- Further (on-going) research should demonstrate how such model can be used to simulate progressive interventions in land and transport policy over space and time.
UNIVERSITY OF TWENTE.

THANK YOU!

MORE INFORMATION:
ALJOUFIE@ITC.NL; ZUIDGEEST@ITC.NL