Bus Rapid Transit (BRT) and urban development in Latin America and India

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AGENDA

- Overview of the LEDS Global Partnership & Transport Working Group

- Presentation: *Bus Rapid Transit (BRT) and urban development in Latin America and India*

- Questions and Answers

- Closing Remarks

- Survey
Mission
Harness the collective knowledge and resources of governments, donors and international organizations, and practitioners in scaling up and strengthening implementation of climate-resilient low emission development around the world.

Objectives
- Strengthen support for LEDS
- Mobilize capacity and advance peer-to-peer learning and collaboration on LEDS
- Improve coordination of LEDS at the country, regional, and global levels.

Launched in 2011, the LEDS GP now catalyzes action and collaboration across more than 120 countries and international organizations.
LEDS GP ORGANIZATIONAL STRUCTURE

**IMPROVED LEDS**

- **REGIONAL PLATFORMS**
  - define priorities, lead peer learning, and support delivery

- **SECRETARIAT**
  - coordinates implementation

- **GLOBAL WORK STREAMS**
  - Provide technical support and training

- **STEERING COMMITTEE**
  - sets strategic direction

- **African LEDS Partnership**
- **Asia LEDS Partnership**
- **Latin America and Caribbean Platform**

**LEDS Planning**
- **LEDS Analysis Models and Tools**
- **Finance Sectors**
EXAMPLES OF LEDS GP SUPPORT

Peer learning and knowledge sharing
- Global and regional workshops and trainings for more than 800 practitioners on LEDS planning, analysis, finance, and sectoral programs

Technical collaboration
- Transportation and Development Impacts Assessment (DIA) toolkits and country assistance
- National LEDS Finance Strategies with Colombia, Peru, and Chile
- No cost expert assistance available on LEDS analysis, finance, and sector measures to all members
  - e.g. support to Mauritius on solar hot water program, Bhutan on transport options, Indonesia on budget allocation, Cambodia on green fund, and Cote D'Ivoire on bio-energy

Understanding and analysis of LEDS benefits
- Application of DIA visual tool with Ghana, Kenya, and Montenegro
- Broader portfolio of shared LEDS communication resources under development

Learn more at: www.LEDSGP.org
LEDS GP – Transport Working Group

- Leaders:
  - EMBARQ, the sustainable transport and urban development program of the World Resources Institute (WRI)
  - United States National Renewable Energy Laboratory (NREL)
  - United Nations Environment Programme (UNEP)

- What do we do?
  - Knowledge management and diffusion
  - Peer-to-peer training and regional workshops
Bus Rapid Transit (BRT) and urban development in Latin America and India

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Outline

I. **Background**
II. Literature review
III. Research questions and methodology
IV. BRT stop typologies in Latin America and India
V. Comparative approach of BRT typologies
VI. Discussion and acknowledgements
Bus Rapid Transit (BRT) and urban development in Latin America and India

Background: BRT

- High quality **bus service** as a **mass transit option**
  - Priority (lanes, intersections)
  - High capacity and level boarding
  - Off-board data collection

- **Latin America** (63.3% worldwide ridership)
- **Asia** (26.4% world ridership)
- **Latin America and Asia world leaders** (89.7% world ridership)

Latin America is the world leader on BRT, with 19,542,283 passengers per day. Asia is emerging as a leader with 8,165,822 passengers per day. The chart shows the growth of BRT systems in Latin America and Asia from 1970s to 2010s.

Source: www.brtdata.org (2014)
BRT and Urban Development

- BRT systems
  - **Cost-effectiveness** and relative flexibility
  - Can mobilize as many *passengers* as most conventional light rail systems
  - Cost-effectiveness of BRT hinges on the ability to have *demand concentrated* along system corridors

- BRT & urban development
  - Experience of *Curitiba* (transport and land use)
  - *Limited empirical evidence* regarding the development impacts that BRT investments cause
Bus Rapid Transit (BRT) and urban development in Latin America and India

Curitiba
Brazil 1974

Quito
Ecuador 1996

Bogotá
Colombia 2000

Ahmedabad
India 2009

Source: Vergel (2011, 2013)
Background: Cities with BRT 1972-2013

Source: adapted from www.brtdata.org (2014)

Bus Rapid Transit (BRT) and urban development in Latin America and India
New view of transit capacity

Bus Rapid Transit – BRT

Passengers / hour direction

<table>
<thead>
<tr>
<th>Mode</th>
<th>Capacity / hour direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>3,000</td>
</tr>
<tr>
<td>LRT</td>
<td>6,000</td>
</tr>
<tr>
<td>BRT</td>
<td>12,000</td>
</tr>
<tr>
<td>Metro</td>
<td>25,000</td>
</tr>
<tr>
<td></td>
<td>45,000</td>
</tr>
</tbody>
</table>

Source: Bus Rapid transit: a review of recent advances (Lloyd Wright, 2012)

© Vergel (2014)
Transit Oriented Development TOD

Attributes of transit-oriented development (TOD):

- Compact and dense
- High land use mixtures
- High-quality pedestrian environment
- Strong coordination between transit and the built environment

Sources: [http://sites.arlingtonva.us/rosslynsector/about/planning-in-arlington/](http://sites.arlingtonva.us/rosslynsector/about/planning-in-arlington/) IPPUC (2011)
Benefits of TOD

- Make **transit use** more viable (TCRP 2008)
  - Provision several transportation modes – efficient manner
- **Concentrates demand** (economies of density)
- Time and costs **savings** for residents
- **Accessibility** benefits (local & regional scale)
- Real estate/neighborhood-community development strategy
  - Efficient **land use and development** around transit stops
- Generates **revenue** for the city
  - Property tax, value capture, ridership, etc.
Motivation

- Generalized perception that the “T” in TOD is rail, not BRT
  - Lack of locational rigidity & permanence
  - Noise & pollution
  - Allure of rails’ newness
  - All this, despite Curitiba’s exemplary approach
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VI. Discussion and acknowledgements
Literature Review: BRT & Prices

- Quasi-experimental methods
  - Bogota: Between 0-15% residential premium (Perdomo et al; Rodriguez & Mojica)
  - Ecatepec: No change due to announcement

- Observational (cross-sectional) methods
  - Seoul (Sung & Cho, 2011)
    - 5-10% residential premium (within 300 m)
    - 3% retail premium (within 300m)
Literature Review: BRT & Density

- BRT expansion increased densities in Bogota (Bocarejo et al, 2012)

- Auto oriented uses, parking, long blocks barriers to Jinan BRT (Thomas & Deakin, 2008)

Source: Bocarejo et al, 2012
Literature Review: TOD typologies

- Prospective, from **visionaries/planners**
  - Encourage strategic planning
  - Guide investment
  - Engage public

- Retrospective, **empirically-based**
  - Descriptive
  - Basis for explicative research
  - Can be used prospectively
Literature Review: TOD typologies

- **Urbanity**
  - Urban and neighborhood TODs (Calthorpe, 1997)
    - Land use, intensity, design, public spaces
  - Regional, community, neighborhood by technology in FL

- **Geography and urbanity**
  - Dominant view (Dittmar & Poticha, 2004)
    - In Sacramento, Denver, San Francisco
    - Core, employment centers, commuter enter, mixed use dense, urban neighborhood
Literature Review: Empirical typologies

- **25 Hong Kong** rail stops
  - **5 types** based on land use, intensity, area

- **27 Phoenix** LRT stops
  - **5 types** based on land use, intensity, socio-demographics and housing

Source: Reconnectingamerica.org
Source: Cervero and Murakami, 2008
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Research Questions

- What is occurring around BRT stops in **Latin America** and **India**?
  - Examine the built environment around BRT stops
  - Develop a typology of environments
    - Help understand where BRT is happening and how
    - Guide decision makers towards possible future scenarios

- What are the factors explaining land development changes and **TOD features** around BRT stops?
Methodology: Latin America

- Collect segment-block-stop-level data
- Reduce data and use it to develop types
- Inclusion criteria
  - > 5 yrs in operation
  - Medium to large city
- Seven cities
  - 16% of worlds’ BRT use
  - 31% of Latin America BRT use

Source: Rodriguez and Vergel (2012)
Methodology: India

- Collect segment-block-stop-level data
- Reduce data and use it to develop types
- Inclusion criteria
  - BRT under operation
  - Medium to large city

- **Indore** 7.19% India BRT use
- **Ahmedabad** 16.85% India BRT use

Source: Vergel (2013), Global BRT Data http://www.brtdata.org/#/country/Asia/India
Methodology: Data collection

BRT Stop Jardim Botanico
Curitiba (Brazil)

BRT Stop (buffer area)

250m

Legend
- BRT Stops
- BRT Corridor

Population Density (Pop/Ha)
- 0 - 13
- 14 - 42
- 43 - 103
- 104 - 208
- 209 - 363

Source: Rodriguez and Vergel (2012)
### Methodology: Audit

- **Land uses, heights, consolidation, density, quality of construction, parking**
- **Public spaces, facilities, pedestrian supports**
- **Pedestrian Environment**

#### Data Scan PEDES

**Source:** Rodriguez and Vergel (2012)
Methodology: BRT Stops

- Identify stops with different conditions
  - Confirmed/reconsidered with local planners

Bogotá | Sao Paulo (Corredor ABD) | Curitiba | Goiânia | Ciudad de Guatemala | Quito | Guayaquil | Indore | Ahmedabad
--- | --- | --- | --- | --- | --- | --- | --- | ---
5 | 7 | 9 | 6 | 9 | 7 | 8 | 12 | 21
4.4% | 13.2% | 8.0% | 31.6% | 50.0% | 8.9% | 16.0% | 57.1% | 19.3%

Methodology: BRT Terminals

- Identify stops with different conditions
  - Confirmed/reconsidered with local planners

31 Latin America

<table>
<thead>
<tr>
<th>City</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogotá</td>
<td>5</td>
<td>71.4%</td>
</tr>
<tr>
<td>Sao Paulo (Corredor ABD)</td>
<td>5</td>
<td>62.5%</td>
</tr>
<tr>
<td>Curitiba</td>
<td>7</td>
<td>23.3%</td>
</tr>
<tr>
<td>Goiânia</td>
<td>5</td>
<td>100.0%</td>
</tr>
<tr>
<td>Ciudad de Guatemala</td>
<td>1</td>
<td>33.3%</td>
</tr>
<tr>
<td>Quito</td>
<td>5</td>
<td>45.5%</td>
</tr>
<tr>
<td>Guayaquil</td>
<td>3</td>
<td>100.0%</td>
</tr>
<tr>
<td>Indore</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Bus Rapid Transit (BRT) and urban development in Latin America and India

- BRT-oriented land uses: commercial, residential, and institutional
- BRT-unsupportive land uses: industrial, industrial & commercial, and vacant

Source: Vergel (2013)
**Bus Rapid Transit (BRT) and urban development in Latin America and India**

**Ahmedabad**

- **BRT-oriented land uses**: commercial, residential, and institutional
- **BRT-unsupportive land uses**: industrial, industrial & commercial, and vacant

**Density of land uses per BRT stop**

(sum of segments by land use / gross area)

**Segment types**

- % seg 2-lanes
- % seg 3-lanes
- % seg-peds

Source: Vergel (2013)
## Methodology: Areas audited

### Segments/BRT stop
(Average 129.5)

<table>
<thead>
<tr>
<th>City</th>
<th>No. BRT Stops &amp; Terminals</th>
<th>Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogota</td>
<td>10</td>
<td>1,773</td>
</tr>
<tr>
<td>Sao Paulo</td>
<td>12</td>
<td>1,223</td>
</tr>
<tr>
<td>Curitiba</td>
<td>16</td>
<td>1,608</td>
</tr>
<tr>
<td>Goiânia</td>
<td>11</td>
<td>1,305</td>
</tr>
<tr>
<td>Guatemala</td>
<td>10</td>
<td>1,316</td>
</tr>
<tr>
<td>Quito</td>
<td>12</td>
<td>1,425</td>
</tr>
<tr>
<td>Guayaquil</td>
<td>11</td>
<td>1,662</td>
</tr>
<tr>
<td>Indore</td>
<td>12</td>
<td>1,114</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>21</td>
<td>3,630</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>115</strong></td>
<td><strong>15,056</strong></td>
</tr>
</tbody>
</table>

### Blocks/BRT stop
(Average 35.44)

<table>
<thead>
<tr>
<th>City</th>
<th>No. BRT Stops &amp; Terminals</th>
<th>Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogota</td>
<td>10</td>
<td>496</td>
</tr>
<tr>
<td>Sao Paulo</td>
<td>12</td>
<td>371</td>
</tr>
<tr>
<td>Curitiba</td>
<td>16</td>
<td>455</td>
</tr>
<tr>
<td>Goiânia</td>
<td>11</td>
<td>388</td>
</tr>
<tr>
<td>Guatemala</td>
<td>10</td>
<td>390</td>
</tr>
<tr>
<td>Quito</td>
<td>12</td>
<td>377</td>
</tr>
<tr>
<td>Guayaquil</td>
<td>11</td>
<td>486</td>
</tr>
<tr>
<td>Indore</td>
<td>12</td>
<td>316</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>21</td>
<td>710</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>115</strong></td>
<td><strong>3,989</strong></td>
</tr>
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</table>

- Segments/BRT stop: 177.30 (Average 129.5)
- Blocks/BRT stop: 49.60 (Average 35.44)
Methodology: Areas audited

<table>
<thead>
<tr>
<th>City</th>
<th># Simple stops</th>
<th>Segments</th>
<th>Blocks</th>
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</thead>
<tbody>
<tr>
<td>Bogota</td>
<td>5</td>
<td>316</td>
<td>96</td>
</tr>
<tr>
<td>Sao Paulo (ABD)</td>
<td>7</td>
<td>302</td>
<td>101</td>
</tr>
<tr>
<td>Curitiba</td>
<td>9</td>
<td>439</td>
<td>144</td>
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<tr>
<td>Goiânia</td>
<td>6</td>
<td>386</td>
<td>123</td>
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<tr>
<td>Ciudad de Guatemala</td>
<td>8</td>
<td>719</td>
<td>223</td>
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<td>Quito</td>
<td>7</td>
<td>465</td>
<td>133</td>
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<tr>
<td>Guayaquil</td>
<td>8</td>
<td>817</td>
<td>240</td>
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<tr>
<td>Indore</td>
<td>12</td>
<td>1,114</td>
<td>316</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>21</td>
<td>3,630</td>
<td>710</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>83</strong></td>
<td><strong>8,188</strong></td>
<td><strong>2,086</strong></td>
</tr>
</tbody>
</table>

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*Segments/BRT stop (Average 82.62)*

*Blocks/BRT stop (Average 23.02)*
Methodology: Factor Analysis

**Built Environment**

- Land Use
- Building Heights
- Density
- Development
- Building heights
- Public Space
- Housing
- Parking
- Sidewalks

**Built Environment**

`X_1 \ldots X_{38}`

**Data matrix**

`O_1 \ldots O_{82}`

**Factor Analysis**

`X_1 \ldots X_{38} F_1 \ldots F_k`

**Data matrix**

`O_1 \ldots O_{82}`

- Factor 1
- Factor 2
- Factor 3
- Factor 4
- Factor 5
- Factor 6
- Factor 7
- Factor 8
- Factor 9

India

Latin America

Source: Rodriguez, Vergel (2012)
Methodology: Cluster Analysis

BRT STOP TYPOLOGY CONCEPT

BRT STOP Type 1

BRT STOP Type 2

BRT STOP Type 3

BRT STOP Type 4

Source: Rodriguez, Vergel (2012)
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# Factor Analysis: Latin America

<table>
<thead>
<tr>
<th>#</th>
<th>Variable</th>
<th>Pedestrian friendly, connected green and public spaces (Factor 1)</th>
<th>Non-core single family attached (Factor 2)</th>
<th>High density residential multifamily (Factor 3)</th>
<th>Undeveloped land (Factor 4)</th>
<th>High condition mixed use areas (Factor 5)</th>
<th>High condition green spaces (Factor 6)</th>
<th>BRT-O public facilities (Factor 7)</th>
<th>Commercial large-scale development (Factor 8)</th>
<th>Consolidated non-industrial fabric (Factor 9)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Facility index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.66</td>
<td></td>
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<td>2</td>
<td>Facility density</td>
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<td>BRT-oriented facility index</td>
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<td></td>
<td>0.54</td>
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<td>4</td>
<td>BRT-oriented facility density</td>
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<td></td>
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</tr>
<tr>
<td>5</td>
<td>Green areas’ density</td>
<td>0.97</td>
<td></td>
<td></td>
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<td></td>
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<td>6</td>
<td>Park density</td>
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<td>7</td>
<td>NMT friendliness</td>
<td>0.94</td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Land use index</td>
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<td></td>
<td></td>
<td>0.59</td>
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<td></td>
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<tr>
<td>9</td>
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<td>0.45</td>
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<td>10</td>
<td>Industrial</td>
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<td></td>
<td></td>
<td>-0.56</td>
<td></td>
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<tr>
<td>11</td>
<td>Residential single family (attached)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
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<td>12</td>
<td>Residential multifamily</td>
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<td></td>
<td></td>
<td></td>
<td>0.82</td>
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<td></td>
</tr>
<tr>
<td>13</td>
<td>Mixed: Industrial-commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Vacant</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Institutional*</td>
<td></td>
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<td></td>
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<tr>
<td>16</td>
<td>Green</td>
<td>0.67</td>
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<td></td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|     | Eigenvalue                                             | 6.64                                                          | 4.94                                      | 4.16                                      | 3.06                                    | 2.24                                    | 1.89                                    | 1.60                             | 1.16                             | 1.02                             |
|     | Cronbach’s Alpha                                       | 0.88                                                          | 0.83                                      | 0.85                                      | 0.85                                    | 0.67                                    | 0.70                                    | 0.69                             | 0.64                             | 0.61                             |

Note: factor loadings <0.40 are left blank.
*Variables with all factor loadings <|0.40|

Source: Rodriguez, Vergel (2012)
## Factor Analysis: Latin America

<table>
<thead>
<tr>
<th>#</th>
<th>Variable</th>
<th>Pedestrian friendly, connected green and public spaces (Factor 1)</th>
<th>Non-core single family attached (Factor 2)</th>
<th>High density residential multifamily (Factor 3)</th>
<th>Undeveloped land (Factor 4)</th>
<th>High condition mixed use areas (Factor 5)</th>
<th>High condition green spaces (Factor 6)</th>
<th>BRT-O public facilities (Factor 7)</th>
<th>Commercial large-scale development (Factor 8)</th>
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Note: factor loadings <0.40 are left blank. *Variables with all factor loadings <|0.40|

Source: Rodriguez, Vergel (2012)
### BRT Typologies: Latin America

#### 1 (n=17)

| Factor 1 | Mean | -0.29 |
| Factor 2 | Mean | -0.46 |
| Factor 4 | Mean | -0.58 |
| Factor 5 | Mean | -0.70 |
| Institutional | Mean | 0.71 |
| BRTO land use | Mean | -0.81 |
| Pop density | Mean | -0.15 |

#### 2 (n=1)

| Factor 1 | Mean | 1.87 |
| Factor 2 | Mean | -2.41 |
| Factor 4 | Mean | -0.82 |
| Factor 5 | Mean | 0.01 |
| Institutional | Mean | 4.63 |
| BRTO land use | Mean | -1.20 |
| Pop density | Mean | -0.31 |

#### 3 (n=7)

| Factor 1 | Mean | 0.23 |
| Factor 2 | Mean | -0.25 |
| Factor 4 | Mean | 0.06 |
| Factor 5 | Mean | -0.46 |
| Institutional | Mean | -0.46 |
| BRTO land use | Mean | -0.62 |
| Pop density | Mean | 0.73 |

#### 4 (n=12)

| Factor 1 | Mean | 0.70 |
| Factor 2 | Mean | 0.17 |
| Factor 4 | Mean | 0.06 |
| Factor 5 | Mean | 0.24 |
| Institutional | Mean | 0.33 |
| BRTO land use | Mean | -0.58 |
| Pop density | Mean | -0.33 |

#### 5 (n=2)

| Factor 1 | Mean | 4.57 |
| Factor 2 | Mean | 0.52 |
| Factor 4 | Mean | -0.16 |
| Factor 5 | Mean | 0.33 |
| Institutional | Mean | -0.58 |
| BRTO land use | Mean | -0.48 |
| Pop density | Mean | 2.53 |

#### 6 (n=11)

| Factor 1 | Mean | -0.39 |
| Factor 2 | Mean | -0.55 |
| Factor 4 | Mean | -0.39 |
| Factor 5 | Mean | -0.50 |
| Institutional | Mean | -0.72 |
| BRTO land use | Mean | -0.07 |
| Pop density | Mean | -0.76 |

#### 7 (n=5)

| Factor 1 | Mean | -0.62 |
| Factor 2 | Mean | -1.05 |
| Factor 4 | Mean | -0.77 |
| Factor 5 | Mean | -0.52 |
| Institutional | Mean | -0.52 |
| BRTO land use | Mean | 0.50 |
| Pop density | Mean | -0.84 |

#### 8 (n=16)

| Factor 1 | Mean | -0.08 |
| Factor 2 | Mean | 0.84 |
| Factor 4 | Mean | 0.46 |
| Factor 5 | Mean | 0.54 |
| Institutional | Mean | 0.17 |
| BRTO land use | Mean | 1.29 |
| Pop density | Mean | -0.16 |

#### 9 (n=5)

| Factor 1 | Mean | 0.10 |
| Factor 2 | Mean | 1.63 |
| Factor 4 | Mean | -0.40 |
| Factor 5 | Mean | -1.35 |
| Institutional | Mean | -0.25 |
| BRTO land use | Mean | 0.13 |
| Pop density | Mean | 1.00 |

#### 10 (n=5)

| Factor 1 | Mean | -0.15 |
| Factor 2 | Mean | -0.51 |
| Factor 4 | Mean | 2.65 |
| Factor 5 | Mean | -0.75 |
| Institutional | Mean | 0.81 |
| BRTO land use | Mean | 0.48 |
| Pop density | Mean | -0.26 |
BRT STOP
TYPE 2
Latin America

BRT STOP
PLAZA GRANDE
Historic Center
QUITO

Pedestrian friendly and public spaces
-2.41

Non-core single family attached
1.87

Undeveloped land
-0.82

Population density
-0.31

Institutional land use

Centrality

Segment density
-1.26

Mean Values (factors and standardized variables)
BRT STOP
TYPE 5
Latin America

Mean Values (factors and standardized variables)

- Pedestrian friendly and public spaces: 4.57
- Non-core single family attached: 0.52
- Undeveloped land: -0.16
- Population density: 2.53
- Institutional land use: -0.26
- Centrality: 0.21
- Segment density: 3.24

BRT TERMINAL
CALLE 80
BOGOTÁ
## Factor Analysis: India

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<th>Variable</th>
<th>BRT-OD Facility-high dense built-up &amp; rickshaws (Factor 1)</th>
<th>Slums NMT friendly &amp; low height (Factor 2)</th>
<th>BRT-OD land uses consolidated and connected (Factor 3)</th>
<th>Green spaces and parks (Factor 4)</th>
<th>High-rise good condition &amp; vacant BRT (Factor 5)</th>
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Note: Factors loading <|0.40| are left blank. *Land use index is the only variable did not load in any factor.
BRT Typologies: India

1 (n=1)

BRT-OD LU: -2.01
Green spaces and parks: -0.69
Entropy: -0.08
Segment density: -0.95
Average block size: 1.17
Sidewalks: -0.45

2 (n=1)

BRT-OD LU: -0.67
Green spaces and parks: 0.10
Entropy: 0.23
Segment density: 0.34
Average block size: -0.74
Sidewalks: -0.61

3 (n=3)

BRT-OD LU: 0.06
Green spaces and parks: 1.14
Entropy: -0.61
Segment density: -0.62
Average block size: -0.10
Sidewalks: 0.19

4 (n=3)

BRT-OD LU: 1.47
Green spaces and parks: -1.04
Entropy: 0.56
Segment density: 0.37
Average block size: 0.01
Sidewalks: 0.97

5 (n=1)

BRT-OD LU: 1.38
Green spaces and parks: 0.13
Entropy: 0.45
Segment density: 0.59
Average block size: 0.81
Sidewalks: 0.53

6 (n=2)

BRT-OD LU: -1.79
Green spaces and parks: -0.09
Entropy: 0.76
Segment density: -0.89
Average block size: 0.37
Sidewalks: -0.71

7 (n=7)

BRT-OD LU: -0.13
Green spaces and parks: -0.43
Entropy: -0.07
Segment density: -0.30
Average block size: -0.41
Sidewalks: -0.34

8 (n=2)

BRT-OD LU: -0.94
Green spaces and parks: -0.47
Entropy: 0.19
Segment density: -1.35
Average block size: 2.78
Sidewalks: 1.50

9 (n=2)

BRT-OD LU: 0.76
Green spaces and parks: -0.21
Entropy: 1.09
Segment density: -0.51
Average block size: -0.07
Sidewalks: 0.26

10 (n=3)

BRT-OD LU: -0.34
Green spaces and parks: -0.47
Entropy: 0.37
Segment density: -1.35
Average block size: 2.78
Sidewalks: 1.50

11 (n=2)

BRT-OD LU: 0.08
Green spaces and parks: -0.58
Entropy: 1.24
Segment density: 1.81
Average block size: -1.03
Sidewalks: -0.80

12 (n=2)

BRT-OD LU: 0.23
Green spaces and parks: 0.39
Entropy: -0.16
Segment density: 2.27
Average block size: -1.11
Sidewalks: -0.86

13 (n=2)

BRT-OD LU: 0.64
Green spaces and parks: -0.07
Entropy: -0.82
Segment density: -0.64
Average block size: -0.12
Sidewalks: -0.02

14 (n=1)

BRT-OD LU: 0.89
Green spaces and parks: -1.22
Entropy: -1.53
Segment density: 0.73
Average block size: -1.16
Sidewalks: -1.45

15 (n=1)

BRT-OD LU: 0.82
Green spaces and parks: 3.46
Entropy: 0.57
Segment density: 0.72
Average block size: -0.91
Sidewalks: 0.73
Mean Values (factors and standardized variables)

- BRT-OD LU consolidated and connected: 0.82
- Green spaces and parks: 3.46
- Entropy: 0.57
- Segment density: 0.72
- Average block size: -0.91
- Sidewalks: 0.73

Bus Rapid Transit (BRT) and urban development in Latin America and India

BRT STOP TYPE 15
India

BRT STOP
SHASTRINAGAR
AHMEDABAD
Bus Rapid Transit (BRT) and urban development in Latin America and India

**BRT STOP**

**TYPE 8**

**India**

**BRTS STOP**

**ISKON MANDIR**

**AHMEDABAD**

-0.94

BRT-OD LU consolidated and connected

-0.47

Green spaces and parks

Entropy 0.19

-1.35

Segment density

Average block size 2.78

Sidewalks 1.50

Mean Values (factors and standardized variables)
Outline

I. Background
II. Literature review
III. Research questions and methodology
IV. BRT stop typologies in Latin America and India
V. Comparative approach of BRT typologies
VI. Discussion and acknowledgements
Bus Rapid Transit (BRT) and urban development in Latin America and India

BRT typology Latin America

Built environment factors per BRT typology
(mean values per cluster)

[Bar chart showing built environment factors per BRT typology with different colors and labels for each category.]

Source: Rodriguez, Vergel (2013)
BRT typology Latin America

Built environment factors per BRT typology
(mean values per cluster)

Source: Rodriguez, Vergel (2013)
BRT typology India

Built environment factors per BRT typology
(mean values per cluster)

1. BRT-OD Facility-high dense built-up & rickshaws
2. BRT-OD land uses consolidated and connected
3. Green spaces and parks

Source: Vergel (2013)
Bus Rapid Transit (BRT) and urban development in Latin America and India

BRT typology India

Built environment factors per BRT typology
(mean values per cluster)

Source: Vergel (2013)

1. Slums NMT friendly & connectivity
2. High-rise good condition & vacant BRT
3. Noncore mixed facing BRT
4. Land use index

ledsgp.org
Comparison BRT typologies

TOD indicators: nonmotorized transport NMT

**Latin America**
(mean value 57.06*, n=82)

**India**
(mean value 155.5*, n=33)

Density of parks, plazas, pocket parks, boulevards, pedestrian alleys, pedestrian bridges, bicycleways
Comparison BRT typologies
TOD indicators: Entropy

Latin America
(mean value 0.56*, n=82)

India
(mean value 0.61*, n=33)

Standardized values for comparison purposes  *non-standardized value

eveness in the distribution of commercial, residential and institutional land uses
Comparison BRT typologies

TOD indicators: Vacant land

Latin America
(mean value 0.113*, n=82)

India
(mean value 0.196*, n=33)

Segments with vacant land within the buffer area
Comparison BRT typologies

TOD indicators: Commercial and parking

**Latin America**
(mean value 0.30*, n=82)

**India**
(mean value 0.16*, n=33)

Segments with commercial land uses and parking (on-street and off-street)
Outline

I. Background
II. Literature review
III. Research questions and methodology
IV. BRT stop typologies in Latin America and India
V. BRT and land development: Bogotá/Quito – Ahmedabad/Indore

VI. Discussion and acknowledgements
Discussion

- **BRT typologies** of urban development in Latin America and India:
  - Several cities in **Latin America** do not have alleys so that usually **blocks** (squares - rectangles) have **four segments**
  - Most cities in **India** have **alleys** generating different block compositions and segments
  - Identification of BRT typologies separately for comparison purposes between two regions at **different stages** implementing BRT
Discussion

- Does the typology capture city specific factors?
  - **Latin America (10 clusters)**
    - BRT type 2 Quito (n=1, Historic center)
    - BRT type 7 Ciudad de Guatemala (n=5)
    - BRT type 3 mostly Brazil (n=6 out of 7)
  - **India (15 clusters)**
    - BRT types 1, 5, 6, 14 and 15 Ahmedabad (n=1)
    - BRT type 2 Indore (n=1)
Discussion

- BRT types with high transit orientation TOD

  - **Latin America:**
    - **BRT type 5** (n=2): Bogota (Portal 80), Guayaquil (Mercado Caraguay)
    - **BRT type 3** (n=7): Curitiba(4), Sao Paulo (2), Goiânia(1), Guayaquil (1)

  - **India:**
    - **BRT type 9** (n=2): Ahmedabad (Anjali; Kankariya Lake)
    - **BRT type 15** (n=1): Ahmedabad (Shastrinagar)
Discussion

- **BRT typologies and TOD indicators:**
  - **NMT:**
    - Latin America (multifamily residential and public spaces)
    - India (presence of slums)
  - **Entropy:** uses are highly mixed but with variations across typologies
    - Latin America (0.56 entropy)
    - India (0.61 entropy)
  - **Vacant land:** urban expansion areas
  - **Commercial and parking:** consolidated areas and big box developments

- Compare with 0.25-0.26 for Atlanta; San Francisco Bay Area; Winston-Salem; Chicago
Discussion

- **BRT** stops and presence of affordable **housing** and informal settlements (slums):
  - Differences:
    - **Latin America**: non-core housing far from activity nodes
    - **India**: core and non-core housing with high levels of pedestrian segments
  - Similarity:
    - Housing built or land occupation before the introduction of the BRT
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TIME FOR Q&A

Questions?
SURVEY

- How did we do?
- Your feedback is important!
YOUR PARTICIPATION IS APPRECIATED

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