Sustainability of innovative urban surfaces

A new approach of assessment
Overview

- Introduction
- State-of-the-art of sustainability assessment methods
- Methodological approach
- Conclusion and outlook
Introduction

Leistner et al. 2018:

• design of urban surfaces is important for, e.g., environmental quality in cities, resilience of cities to climate change
• urban surfaces have considerate building physical and sustainability related potential
• innovations are essential for realising this potential

→ Sustainability assessment of innovative urban surfaces
State-of-the-art of sustainability assessment methods

Challenges in assessing innovations in the field of urban surfaces:

- Multitude of processes occurring during use phase of an urban surface
- Multitude of requirements are placed on urban surfaces
- Potential impacts in all three dimensions of sustainability
- Definition and categorisation of urban surfaces and innovations
## Methodological approach

Sustainability assessment system of urban surfaces

<table>
<thead>
<tr>
<th>System analysis</th>
<th>Scenario building</th>
</tr>
</thead>
</table>
| - Description of urban surface  
- Design of life cycle of urban surface | - Identification of suitable innovations  
- Selection of innovation  
- Design of life cycle of innovation  
- Building of a baseline and comparison scenario |

### Goal and scope definition

#### Modelling
- Life cycle inventory analysis (for quantitative indicators)  
- Assessment of indicators and impact category groups

#### Interpretation
- Analysis of results  
- Discussion  
- Recommendation to the municipality

Based on (Maier *et al.* 2016) and (Wang *et al.* 2018).
Methodological approach
Definition and categorisation of urban surfaces

Urban surfaces: surfaces that interact in public outdoor spaces within an urban context, e.g., streets, public parks, walkways.
Methodological approach
Definition and categorisation of urban surfaces

Material:
- Asphalt
- Cobblestone
- Concrete

Requirements:
- Safety
- Usability
- Durability

Function:
Space for movement of non-pedestrian traffic

(Photos: 27.09.2018)
Methodological approach
Urban surfaces, management processes and input/ output flows

<table>
<thead>
<tr>
<th>Urban surface category</th>
<th>Subcategories</th>
<th>Management processes</th>
<th>Input flows</th>
<th>Output flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green spaces</td>
<td>Public parks, playgrounds</td>
<td>Fertilising, weeding</td>
<td>Water, fertiliser</td>
<td>Green waste</td>
</tr>
<tr>
<td>Traffic areas</td>
<td>Streets, cycleways, pavements</td>
<td>Cleaning, winter service, modernisation</td>
<td>Gritting salt, water</td>
<td>Dust</td>
</tr>
<tr>
<td>Building spaces</td>
<td>Roofs, facades</td>
<td>Cleaning, watering</td>
<td>Water</td>
<td>Green waste</td>
</tr>
<tr>
<td>Barriers</td>
<td>Stone walls, noise barriers</td>
<td>Repair, replacement</td>
<td>Stones, wooden slats</td>
<td>Rubble</td>
</tr>
</tbody>
</table>
Methodological approach
Assessment of urban surfaces

Quantification:

• Functional equivalent in accordance with DIN EN 15978

• Example:

  Providing 1 m$^2$ of street for 1 year that meets its functional and technical requirements, reference unit [m$^2$a]
Methodological approach
Life cycle of urban surfaces

Information on the life cycle of an urban surface

<table>
<thead>
<tr>
<th>A 1-3</th>
<th>A 4-5</th>
<th>B 1-7</th>
<th>C 1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production phase</td>
<td>Construction phase</td>
<td>Use phase</td>
<td>End-of-life phase</td>
</tr>
<tr>
<td>A1 Raw material procurement</td>
<td>A4 Transport</td>
<td>B1 Use</td>
<td>C1 Dismantling/Demolition</td>
</tr>
<tr>
<td>A2 Transport</td>
<td>A5 Construction/Installation</td>
<td>B2 Maintenance</td>
<td>C2 Transport</td>
</tr>
<tr>
<td>A3 Production</td>
<td></td>
<td>B3 Repair</td>
<td>C3 Waste processing</td>
</tr>
<tr>
<td>B6 Energy consumption during use</td>
<td>B4 Replacement</td>
<td>B7 Water consumption during use</td>
<td>C4 Disposal</td>
</tr>
<tr>
<td></td>
<td>B5 Modernisation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on DIN EN 15978:2012-10
Methodological approach
Life cycle of urban surfaces

Information on the life cycle of an urban surface

A 1-3
Production phase
A1 Raw material procurement
A2 Transport
A3 Production

A 4-5
Construction phase
A4 Transport
A5 Construction/Installation

B 1-7
Use phase
B1 Use
B2 Maintenance
B3 Repair
B4 Replacement
B5 Modernisation

C 1-4
End-of-life phase
C1 Dismantling/Demolition
C2 Transport
C3 Waste processing
C4 Disposal

Based on DIN EN 15978:2012-10
Methodological approach
Life cycle of urban surfaces

Information on the life cycle of an urban surface

<table>
<thead>
<tr>
<th>A 1-3</th>
<th>A 4-5</th>
<th>B 1-7</th>
<th>C 1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production phase</td>
<td>Construction phase</td>
<td>Use phase</td>
<td>End-of-life phase</td>
</tr>
<tr>
<td>A1 Raw material procurement</td>
<td>A4 Transport</td>
<td>B1 Use</td>
<td>C1 Dismantling/Demolition</td>
</tr>
<tr>
<td>A2 Transport</td>
<td>A5 Construction/Installation</td>
<td>B2 Maintenance</td>
<td>C2 Transport</td>
</tr>
<tr>
<td>A3 Production</td>
<td></td>
<td>B3 Repair</td>
<td>C3 Waste processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B4 Replacement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B5 Modernisation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B6 Energy consumption during use</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B7 Water consumption during use</td>
<td></td>
</tr>
</tbody>
</table>
Methodological approach
Life cycle of urban surfaces

Information on the life cycle of an urban surface

<table>
<thead>
<tr>
<th>A 1-3</th>
<th>A 4-5</th>
<th>B 1-7</th>
<th>C 1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production phase</td>
<td>Construction phase</td>
<td>Use phase</td>
<td>End-of-life phase</td>
</tr>
<tr>
<td>A1 Raw material procurement</td>
<td>A4 Transport</td>
<td>B1 Use</td>
<td>C1 Dismantling/Demolition</td>
</tr>
<tr>
<td>A2 Transport</td>
<td>A5 Construction/Installation</td>
<td>B2 Maintenance</td>
<td>C2 Transport</td>
</tr>
<tr>
<td>A3 Production</td>
<td></td>
<td>B3 Repair</td>
<td>C3 Waste processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B4 Replacement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B5 Modernisation</td>
<td>C4 Disposal</td>
</tr>
<tr>
<td>B6 Energy consumption during use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B7 Water consumption during use</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on DIN EN 15978:2012-10
Methodological approach
Life cycle of urban surfaces

<table>
<thead>
<tr>
<th>Information on the life cycle of an urban surface</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A 1-3</strong> Production phase</td>
</tr>
<tr>
<td>A1 Raw material procurement</td>
</tr>
<tr>
<td>A2 Transport</td>
</tr>
<tr>
<td>A3 Production</td>
</tr>
<tr>
<td><strong>A 4-5</strong> Construction phase</td>
</tr>
<tr>
<td>A4 Transport</td>
</tr>
<tr>
<td>A5 Construction/Installation</td>
</tr>
<tr>
<td><strong>B 1-7</strong> Use phase</td>
</tr>
<tr>
<td>B1 Use</td>
</tr>
<tr>
<td>B2 Maintenance</td>
</tr>
<tr>
<td>B3 Repair</td>
</tr>
<tr>
<td>B4 Replacement</td>
</tr>
<tr>
<td>B5 Modernisation</td>
</tr>
<tr>
<td><strong>C 1-4</strong> End-of-life phase</td>
</tr>
<tr>
<td>C1 Dismantling/Demolition</td>
</tr>
<tr>
<td>C2 Transport</td>
</tr>
<tr>
<td>C3 Waste processing</td>
</tr>
<tr>
<td>C4 Disposal</td>
</tr>
</tbody>
</table>

- B6 Energy consumption during use
- B7 Water consumption during use

Based on DIN EN 15978:2012-10

09/12/2019
Methodological approach
Life cycle of urban surfaces

Information on the life cycle of an urban surface

- **A 1-3**: Production phase
  - A1: Raw material procurement
  - A2: Transport
  - A3: Production

- **A 4-5**: Construction phase
  - A4: Transport
  - A5: Construction/Installation

- **B 1-7**: Use phase
  - B1: Use
  - B2: Maintenance
  - B3: Repair
  - B4: Replacement
  - B5: Modernisation

- **C 1-4**: End-of-life phase
  - C1: Dismantling/Demolition
  - C2: Transport
  - C3: Waste processing
  - C4: Disposal

B6: Energy consumption during use
B7: Water consumption during use

Based on DIN EN 15978:2012-10
Methodological approach
Innovations in the field of urban surfaces

Definition of innovation (based on Rogers 1983):
- idea, practice or object that has the potential to optimise urban surfaces, and
- is perceived as new by the municipality

<table>
<thead>
<tr>
<th>Type of innovation</th>
<th>Examples for streets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative surface material</td>
<td>Sound-absorbing surface material</td>
</tr>
<tr>
<td>Innovative machine/ technology</td>
<td>Innovative street cleaning machine</td>
</tr>
<tr>
<td>Innovation regarding management process</td>
<td>Innovative weeding process</td>
</tr>
</tbody>
</table>
Methodological approach
Innovations in the field of urban surfaces

Definition of innovation (based on Rogers 1983):
• idea, practice or object that has the potential to optimise urban surfaces, and
• is perceived as new by the municipality

<table>
<thead>
<tr>
<th>Type of innovation</th>
<th>Examples for streets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative surface material</td>
<td>Sound-absorbing surface material</td>
</tr>
<tr>
<td>Innovative machine/ technology</td>
<td>Innovative street cleaning machine</td>
</tr>
<tr>
<td>Innovation regarding management process</td>
<td>Innovative weeding process</td>
</tr>
</tbody>
</table>
Methodological approach
Life cycle of product innovations

In accordance with ISO 14040:2009-11
Methodological approach

Interactive life cycle scheme – example: Street

- **Life cycle of snow plough**
  - Raw material and fuel acquisition
  - Production of precursors
  - Production of final product
- **Life cycle of innovative surface material**
  - Raw material and fuel acquisition
  - Production of precursors
  - Production of final product
- **Life cycle of innovative street cleaning machine**
  - Raw material and fuel acquisition
  - Production of precursors
  - Production of final product

Life cycle of street

- Production (A1-3)
- Construction (A4-5)
- Use (B1-7)
- Winter service
- Modernisation
- Street cleaning
- End-of-life (C1-4)

End-of-life: Disposal or Recovery
Methodological approach
Interactive life cycle scheme - general
**Methodological approach**

Sustainability assessment system of urban surfaces

**Methodological approach:**

- Operationalises Life Cycle Sustainability Analysis (LCSA) Framework
- Uses Life-cycle thinking
- Uses indicators based on the Sustainable Development Goals (SDGs)
- Based on methodologies by (Maier *et al.* 2016) and (Wang *et al.* 2018)

➢ Decision support for municipalities
Methodological approach
Life cycle scheme embedded in the assessment system

Adapted from (Maier S 2016)
Conclusion and outlook

• Starting point for sustainability assessment of innovations in the field of urban surfaces

• Challenges:
  • Process innovations
  • Innovations that change the functions of an urban surface
  • Data availability (municipal level)

• Next steps:
  • SDG-based indicator system
  • Application to case study
Thank you!

Kristina Henzler

e-mail KristinaHenzler@gmx.de

University of Stuttgart
Institute for Acoustics and Building Physics
Department for Life Cycle Engineering (GaBi)
Pfaffenwaldring 7, 70569 Stuttgart, Germany
Acknowledgments

This research is funded by the Federal Ministry of Education and Research – BMBF as part of the BUOLUS project (Bauphysikalische Gestaltung urbaner Oberflächen für nachhaltige Lebens- und Umweltqualität in Städten – BUOLUS).
References

- Maier S, Beck T, Francisco Vallejo J, Horn R, Söhlemann J-H and Nguyen T 2016 Methodological approach for the sustainability assessment of development cooperation projects for built innovations based on the SDGs and life cycle thinking *Sustainability* **8** 1006
- DIN EN 15978:2012-10 *Nachhaltigkeit von Bauwerken - Bewertung der umweltbezogenen Qualität von Gebäuden - Berechnungsmethode*
References (cont.)

- DGNB GmbH 2018 *DGNB system – New buildings criteria set: Environmental quality ENV1.1 / Building life cycle assessment*