Multi-objective decision support for neighborhoods

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Background

With the Green Deal, the European Union highlights the urgency of climate change mitigation and adaptation. The building sector is responsible for 38% of CO_2 emissions worldwide and offers high potential for improvement [1]. However, previous approaches to neighborhood development often take a one-sided view, as a holistic assessment of the complex urban system seems hardly feasible. Therefore, it is important to identify frameworks that combine climate change mitigation and adaptation while contributing positively to the regeneration of our planet's biocapacity.

The Social-Ecological-Technological Systems (SETS) approach represents a common base for achieving such a holistic view of the built environment (Fig. 1). It fosters the systemic consideration of urban areas and provides a framework for allocating interactions [2].

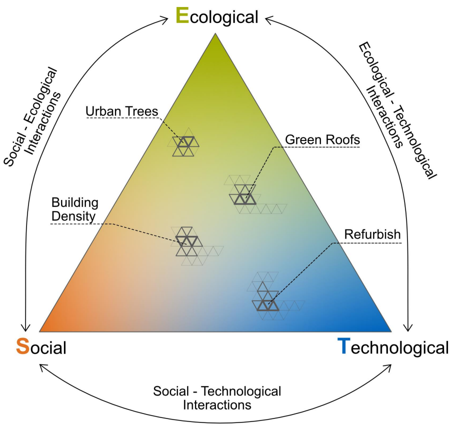

Fig. 1 Exemplary character of neighborhood interventions in the Social-Ecological-Technological Systems framework. Own illustration based on [2].

Goals of the Research

This dissertation aims to:

- Define the terms 'Synergy' and 'Trade-off' with regard to the built environment
- Develop a simulation model that can simulate the interactions between buildings and outdoor space from a lifecycle perspective
- Show the relevance of these interactions for decision-making in urban neighborhood development
- Make the knowledge of resulting synergies and trade-offs accessible to professionals in urban planning

Methodology

First, existing usages of the terms synergy and trade-off in various disciplines are analyzed. These interpretations are then transferred to the building sector and allow to derive corresponding evaluation indicators and establish a generic process for optimized multi-objective decision support in neighborhood development, called here the *Urban Systems Exploration* [3]. Parametric building and neighborhood models allow to investigate the synergetic effect of measure combinations as well as multi-objective trade-offs with regard to lifecycle-based global warming potential, lifecycle costs, and outdoor thermal comfort (Fig. 2). Finally, expert interviews are conducted to ensure the findings' usability.

Results

The application of *Urban Systems Exploration* reveals a trade-off between the three objectives. Figures 3 and 4 show the Pareto Front and exemplarily inputs of a selected area of Pareto-optimal solutions.

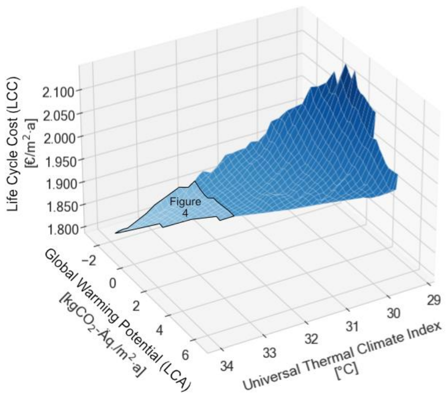

Fig. 3 Pareto Front of the neighborhood model for the three target dimensions global warming potential, life cycle costs, and outdoor thermal comfort.

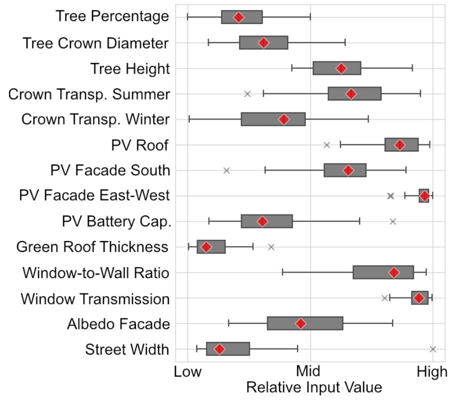

Fig. 4 Distribution of the input values of an area with low costs and low global warming potential but high outdoor heat stress. The corresponding Pareto Front area is highlighted in Fig. 3.

Key Findings

- Urban vegetation, high building energy standards, and photovoltaic surfaces contribute to the **parallel improvement** of lifecycle-based global warming potential, lifecycle costs, and outdoor thermal comfort.
- These planning variables are well suited to control Pareto-optimal trade-offs and thus **adapt designs to the neighborhood context**.
- The need for a **systemic view of urban space** for the sustainable transformation of the building sector is evident.
- It is recommended to adopt a **multi-objective approach in planning** processes and to base decisions on a complete exploration of the scope for action.

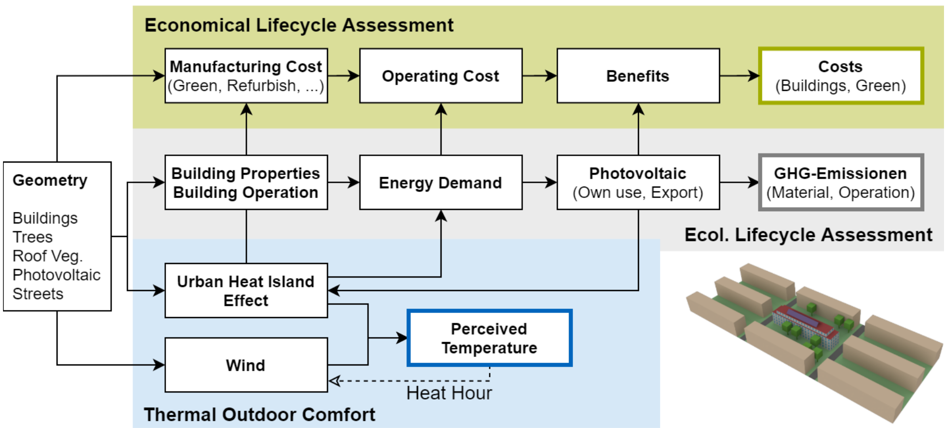

Fig. 2 Simplified representation of information flows within the developed neighborhood simulation model.

WE WALK THE TALK

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Sources
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[2] T. McPhearson et al. „A social-ecological-technological systems framework for urban ecosystem services", One Earth, 5, pp. 505-518, 2022. https://doi.org/10.1016/j.oneear.2022.04.007
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3 GOOD HEALTH AND WELL-BEING | 7 AFFORDABLE AND CLEAN ENERGY | 11 SUSTAINABLE CITIES AND COMMUNITIES | 13 CLIMATE ACTION | 15 LIFE ON LAND

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