Dynamic Assessment of Nature Based Solutions Through Urban Level LCA
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The problem of urbanization

CITIES consume generate 75% of the world's resources, of GHG emissions globally

..and are responsible for 60 - 80% of energy consumption around the world.
Nearly 90% of cities are threatened by economic loss due to natural disasters.

BRE, “Cities as systems: BRE solutions for urban environments,” 2015.
Nature-based solutions (NBS) are actions which are inspired by, supported by or copied from nature. They are
- multi-functional,
- resilient,
- resource efficient,
- locally adaptable

They can address a variety of societal challenges with the potential to contribute to green growth, 'future-proothing' society, fostering citizen well-being, and providing business opportunities.
The goal of this project was to “green” the façade of a building of the Vienna Magistrate (“MA48”), thereby creating ecological niches and habitats for many kinds of insects and birds, and having positive effects on the surrounding indoor and outdoor climates.

The first measurements have shown that the building’s heat loss in winter was reduced by up to 50%. The summer cooling through the “green skin” was equivalent to that of about 45 air conditioning units.
Faced with many sustainability challenges, urban assessments help cities to identify main bottlenecks regarding resilience, vulnerability to climate change, food, water and energy security issues and develop sound strategies or policies to tackle these.

Through LCA, it is possible to go beyond inventorying direct consumption and emissions, and consider transboundary or cross media effects embedded in urban flows and stocks.
NBS are among the strategies that can benefit from a **holistic assessment** methodology due to their **multiple benefits** under themes including greenhouse gas emissions, biodiversity, water, urban food, air and health. The assessment framework targeting NBS should be able to address this **multi-layered aspect of NBS**.

LCA is a suitable methodology for this purpose as it covers various environmental mechanisms revealing information on different impacts at mid-point and larger scale damage categories at end-point.
This is only possible by means of reflecting the **complexity of urban systems**, which is comprised of numerous layers of functional sub-systems.

To be able to reach the desired level of representation of complex urban systems, the conceptual models developed during system boundary definition stage of LCA can benefit from **urban metabolism approach**.
Urban metabolism is defined as “a broad range of quantitative methods that attempt to conceptualize urban areas as organisms, requiring goods and energy to maintain functionality and support growth, while emitting waste as a by-product”.

Adapted from [http://www.sume.at/urban_metabolism](http://www.sume.at/urban_metabolism)
LCA should be supplemented with additional tools.

Integrating data generation methods such as BIM and dynamic social assessment can remedy challenging implementation of urban metabolism due to requirement of high amount of data.
Agent based Modelling (ABM)

ABM is a computational tool that studies how macro effects emerge from micro scale behavioral patterns among heterogeneous social agents, which are evolving, autonomous and interacting.

ABM simulations handle the mathematically abstracted environment and the interactions with the involved entities in time series iterations.

This includes the spatial urban data in the form of GIS, BIM and CIM, material and energy flow data following urban metabolism approach, as well as weather and climate related time series data especially if climate change resilience is studied.
Developing an integrated assessment platform for NBS

Nature4Cities aims to integrate multiple tools with techniques and modeling abilities at different scales within a single platform that covers economic, social and environmental aspects of NBS.

The environmental assessment module is planned to handle the relation between the urban metabolism and social wellbeing through ABM along with LCA for the assessment of environmental impacts.

The dynamic assessment will cover the changing nature of this interaction. Supply of flows and behaviors of the population influences the decisions, resulting in changes in the settlement patterns and creating or reducing demand in the flows over time.
Models and analyses urban nexus based on urban metabolism concept

Analyses sustainability actions (e.g. nature based solutions and energy efficiency measures)

Agent based modelling to assess social aspects of sustainability measures

- An indicator-based assessment methodology with a life cycle thinking
- Extremities and hotspots identified and performance of mitigation alternatives analyzed
- Support informed decision-making based on desired performance patterns over time.
BIM digitally represents a building or built object, attributing physical and functional properties gathered from all contributors to the design and implementation.

It provides precise data for the built environment into the urban metabolism model enabling collaboration between different stakeholders through interoperable, shared representation of the object.

Object level modelling for NBS offers to analyse different impacts at local scales such as regulating functions related to thermal comfort.
Many cities are joining the Covenant of Mayors initiative supporting the sustainable energy policies of local governments’ to reduce their carbon emissions at least 20% until 2020.

*Sustainable energy and carbon action plans (SECAP)* entail development of urban GHG inventories, identification of possible strategies for reduction of emissions and quantify their effectiveness.
Integrating BIM and new opportunities | Sustainable Energy and Carbon Action Plans

- Design Builder software building energy modelling interface for Energy+
- Time series energy consumption data for the building models
- Building model data to EPESUS Cities
- Extrapolation to building masses drawn on GIS interface of the city
- Establishment of baseline and study of intervention scenarios
Such integration of BIM with GIS creates opportunities for utilization of BIM for entire cities, which is also referred as City Information Model (CIM).

With the sustainability assessment platforms such as EPESUS, now it is possible to
- Complement **scenarios** with real data
- Model **energy consumption**
- Determine GHG emissions and **life cycle impacts**
- **Visualize** the results for instance in the form of emission heatmaps using GIS

This approach is invaluable for assessing the most desired effects of NBS such as
- **Urban heat island mitigation** in areas with high reflectivity surfaces and dense population
- **Pollution control** in areas with high energy consumption or density
- Other local **ecosystem services** such as biodiversity support
- **Areas' desirability or accessibility** for urban agents and behavioral impact (with the aid of ABM).
Conclusions: The Environmental Assessment of Nature Based Solutions
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ABM reveals the impacts of NBS in behavioral patterns that result in changes in the urban metabolism, providing dynamic assessment results. Established BIM tools are capable of providing time series data, which is a promising area for enhancing dynamic urban level assessment.

Rendering the multi benefit and interlinked nature of NBS through efficient modelling of the urban system and collecting reliable data for this model with the potential of forecasting temporal patterns.
Thank you for your attention