Environmental assessment of sustainable urban projects (eco-neighborhoods) through NEST, a decision support tool for early stage urban planning

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Context and Motivation

Urban planning is facing a high performance demand regarding environmental quality (resources consumption, waste production, emissions …), particularly at district scale. However, the concept of sustainable urban development often loses its core substance when opposed to practice realities of the design and implementation of urban projects. Then, how to ensure the effective consideration of the environment and the limitation of the project impacts?

As an answer, we developed NEST (Neighborhood Evaluation for Sustainable Territories): a tool that uses the 3D models of urban projects for quantitative assessment of their environmental impacts. NEST addresses the early design stage and is mainly based on Life Cycle Analysis (LCA) to assess the environmental impacts of projects.

NEST tool

NEST was developed through a PhD thesis (Grace Yepez-Salmon 2011) focused on "Environmental assessment of eco-neighborhoods" in Nobatek and the GRECAU laboratory (ENSAPBx). NEST undertakes the assessment of eight indicators: environmental (Energy, CO_2, Land use, waste, air quality, water), economic (project cost) and social (user's satisfaction). The indicators were conceived associating a scientific approach to measuring environmental, social and economic impacts as well as operational urban planning objectives.

Energy, CO_2 and Land Use indicators are based on LCA. The neighborhood is considered as an "object" responsible for environmental impacts associated with its location, implementation, construction and operation. This "object" is made of complex elements that are simplified in the sketch-up phase in which the focus is on the implantation site, public spaces, basic building design (volume, orientation …), green spaces, roads and parking lots. The LCA at the neighborhood scale comes from an aggregation of the respective LCA of these elements.

Each NEST indicator has been thought to match operational issues faced by urban planners. Indeed, through its broad range of indicators, NEST ensures that numerous dimensions of urban sustainability are taken into account: materials and energy consumption, land occupation, water and waste management, transportation, accessibity …

Assessment of two scenarios for a new neighborhood

NEST was experimented on several urban projects in France allowing for its validation in terms of quality and capacity to generate helpful interactions between project stakeholders (urban planner, developer, mayor, technicians …) on sustainability issues.

Comparing various planning alternatives is facilitated by NEST so that urban planners can improve their proposal. This type of analysis has been conducted, together with the design team, on a new development project for a peri-urban area located in the French “Pyrénées Atlantiques”.

The project was to create a sustainable neighborhood (2, 66 acres) in a small community located 10 km from the agglomeration. Current land occupation was characterized as follow: 50% artificial, 30% agricultural, 10% urban land, 10% vacant green land. The population carrying capacity of the site was set to 300 people (critical for the impact calculation, emphasizes the importance of density).

Two scenarios were established with the design team: one with a stronger investment on sustainability (scenario 1) and another being representative of “business as usual” planning approaches (scenario 2). Each scenario responds to the same initial program (regarding equipments, parks, roads, parking and housing) but in different ways, leading to differences in terms of impacts, quality of life, usage and technical answers. These choices result in another difference between scenarios regarding the distribution of population (more active people in scenario 1). At transport level, scenario 1 includes more public transportation than scenario 2. The main economic activity area being located 10 km away, this point is really significant to consider.

Our analysis allowed visualizing the two alternatives based on two different urban principles and demonstrated the interest of such quantitative assessment. Sustainability is a complex matter for urban planning and quantitative assessment of environmental impacts in line with urban planning practice makes it more tangible and realistic to address.

In the first scenario the inhabitant is clearly less energy consumer (-41%), emits less green house gases (-16%), generates less non recyclable waste (-25%), consume less potable water (-47%), leads to lower outside air pollution (-20%) and shows a better satisfaction. It is also important to note that the neighborhood includes more comfortable buildings with less resource and hosts an inhabitant capacity 40% greater. Cost analysis is also an important part of the assessment and may generate contrast with the environmental assessment. For now, NEST only accounts for an estimate of investment needs for each scenario and requires further research to shift to an overall view of the project lifecycle economics.

This study highlighted the relevance of an evaluation process for the early stage of urban project design. NEST allowed for a new knowledge-based design approach. NEST evaluation was really complementary to the planner’s design skills and was a powerful mean to emphasize the dialogue about sustainability performance between the design team, engineers and the local city.

Next developments on physical ambiances

NEST development was based on two observations:

- Urban planners lack of resources to take into account the environmental impacts of their projects early enough
- Urban sustainability cannot be addressed through a monocriteria optimization approach (e.g. building energy efficiency). It requires a multicriteria approach enabled by a quantitative-based decision support tool

To help urban planners make the best compromises between various sustainability dimensions, some new developments are in progress. Among others we are working on taking into account urban physical ambiances (solar radiation, natural light, wind, humidity and acoustics) as design inputs. We are convinced that this is particularly relevant at the early design stage for two reasons:

- Consideration of physical ambiances can put designers on the right path for a globally optimized design of public spaces and buildings layout
- Physical ambiances set up the comfort conditions in exterior public areas (determining usage and occupancy) and interact with building energy efficiency (through potential solar gains, heat gains, wind exposure …)

There are clear advantages in treating physical ambiances as design inputs, however it remains challenging. At the design stage there is often a lack of data and a lack of budget to address these issues that classically require data and money-intensive simulations.

The development of a decision support module to address these topics within NEST environment requires a significant amount of research that is currently being carried out in Nobatek through a PhD thesis with the CyVi research unit (Life Cycle Analysis Platform of Bordeaux University) as well as the GRECAU laboratory (National School of Architecture and Landscape of Bordeaux) and theCERMA laboratory (National School of Architecture of Nantes).

The aim of this research is to provide urban planners with a simple decision support tool allowing them to take informed decision regarding the treatment of physical ambiances when establishing masterplans as well as issuing guidelines for the architects based on their analysis of physical ambiances.