Sustainability assessment of urban districts: benchmark for quality of physical environment

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ABSTRACT
The fast and uncontrolled emergence of a will to promote sustainable development in the field of building construction generates new requirements for urban development. Besides technical solutions, project managers or urban planners must take into consideration the overall impact of his project on the local and global environment as well as social trends, economic development, health and safety for users. Integration of a huge number of evaluation criteria makes the assessment of such strategy very hard to carry out without a real methodological work. This paper proposes a first methodological approach in order to evaluate sustainability at the district scale. This methodology allows actors in the building sector to consider different sustainable alternatives for a project. The methodology is based on 8 objectives: four of them concern social and economical aspects and are not addressed now. The next four objectives are Preserve the resources (RES), Preserve the ecosystem (ECO), Improve the quality of the physical environment (AMB for "Ambiance") and Preserve health and manage risks (RIS). Each objective is assessed by a set of indicators, thus professionals can evaluate quantitatively different alternatives of a district project planning by means of Amoeba diagrams. Also, this methodology is a contribution to the French research project ADEQUA (Wurtz et al., 2003) funded by French Ministry of Capital Works (RGCU and PUCA) and by the ADEME. The present article focuses on the methodology and the objectives related to physical environment characterisation.

1. INTRODUCTION
The multi criteria approach is becoming more and more predominant in the building sector: new construction or refurbishment operations have now to answer to numerous criteria, often contradictory. Evolution of techniques, knowledge and computational capacity has lead to a necessary opening of the scale of study. The building cannot be anymore studied without taking into account urban environment. Choice of the scale of study is linked to actors involved, affordable level of detail and temporal limits. We propose a methodology to assess and compare different planning alternatives of a district. This work is supported by the French Research Project ADEQUA (Wurtz et al., 2003) funded by French Ministry of Capital Works (RGCU and PUCA) and by the ADEME. The present article focuses on the methodology and the objectives related to physical environment characterisation.

2. THE ADEQUA METHOD
To fill the niche related to multi criteria analysis request, this method aims to offer a decision aid during the planning of a district project.
2.1 Methodological framework

Consequences of planning projects concern local and global scale such as the town or the planet. And planning projects are also related to different scales, from the building to the territory. Each project has intrinsic specificities and Figure 1 shows some of them related to energy consumption.

According to (Owens, 1986), ground occupation and urban planning can significantly influence the energy consumption of a community. The complexity related to a project assessment is increasing with the scale of study when maintaining a level of detail and a constant number of assessment points, as shown Figure 1. District has been chosen as an intermediate between a too narrow scale and an overabundant complexity. A larger scale may raise problems in collecting data and running simulations. District offers a coherent life environment and is adapted to solve numerous problems such as waste management or nuisance reduction (Cherqui et al., 2004). Moreover, this scale emphasis dialogue between local authority, (future) inhabitants, associations, urban planner and project manager.

The construction process is a team work leaded by the project manager and it is not a sequence of steps. Involvement is a necessary basis for success: thus the Adequa method has to be clear in order to be understood by everyone.

2.2 General principles

The main objective of the method is to aid decision through the visualization of consequences of a planning project. Consequences concern Life Cycle Analysis of buildings of a district, from construction phase to demolition, including operation phase. Information has to be concise in order to allow a general picture but should not be summarized to a unique note. Chosen approach uses 8 objectives (introduced in the following section) assessed with a set of indicators (Fig. 2). Majority of indicators are quantified. Since alternatives of a district planning are assessed, comparison is based on Amoeba diagram (Lopez-Ridaura et al., 2002; Ten Brink et al., 1991) as shown figure 6. This kind of visualization offers comprehension and representation advantages and its limits have been well identified (Cherqui et al., 2004).

Different project alternatives are assessed and compared through representation of the different objectives with a dashboard.

Convention is following: best value is always maximum value of diagram and so all indicators are of the type “more is better”. Alternatives' comparison is visual: Amoeba diagram offers a clear and general representation of all indicators and their associated values. Secondly, two solutions can be easily compared, showing weakness and advantages of each alternative.

3. OBJECTIVES AND ASSOCIATED INDICATORS

From the project ADEQUA (Wurtz et al., 2003), a French consortium representing different actors of planning project has proposed a set of objectives based on international and national priorities (Cherqui et al., 2005). The chosen objectives are voluntary limited in number in order to offer a comprehensive and compact vision (Jesinghaus, 1999, Dhakal, 2002, Lopez-Ridaura et al., 2002, Ronchi et al., 2002). Among the 8 objectives chosen (Table 1), 4 have been studied and 4 will be studied in another project involving socio-economic competences. For each objective, a set of associated indicators is defined.

Our present research focuses mostly on the objective "Improve quality of the physical envi-


Table 1: Objectives for the sustainable planning of a district, the 4 objectives in italic have been studied.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasize heritage</td>
<td>Preservation and valorisation of different heritage (natural, architectural, historical, etc.)</td>
</tr>
<tr>
<td>Support local development</td>
<td>Encourage economic and cultural development</td>
</tr>
<tr>
<td>Reinforce quality of social life</td>
<td>Create and develop a community and encourage social links between inhabitants</td>
</tr>
<tr>
<td>Promote the district</td>
<td>Improve integration of the district in the city and link the district to surroundings districts</td>
</tr>
<tr>
<td>Preserve resources</td>
<td>Preserve and enhance natural resources</td>
</tr>
<tr>
<td>Protect ecosystem</td>
<td>Minimize rejection which can be injurious for fauna and flora</td>
</tr>
<tr>
<td>Preserve health and manage risks</td>
<td>Improve health and safety of inhabitants</td>
</tr>
<tr>
<td>Improve quality of physical environment</td>
<td>Preserve and enhance quality of local environment for users</td>
</tr>
</tbody>
</table>

3.1 Indoor comfort

Characterization of indoor comfort concerns indicators related to hydrothermal comfort, visibility, natural lightning potential and indoor space. Hydrothermal comfort is first assessed with a quantitative notation (between 0 and 10) translating project manager's intention relative to the level of comfort expected. Hydrothermal comfort is secondly characterized with a rate of discomfort. Rate of discomfort corresponds to the period of occupation when indoor temperature is above 27°C or below 16°C. It is assessed with a building energy simulation code. Visibility is the fraction of sky visible to the inhabitants from the inside. That is to say the mean view factor between sky and building's façades of a district. Natural lightning potential is estimated by dividing, for each building, the total glazed surface by the total habitable surface. Indoor space corresponds to mean habitable space available per inhabitants.

3.2 Outdoor comfort

Outdoor environment is characterized with acoustical comfort, outdoor visibility and sunshine. Acoustical comfort is quantified with 4 sub-indicators: percentage of façades' surface under noise level of 70 dB(A) during day, 65 dB(A) during night, percentage of ground (1.5 meters above ground) under noise level of 70 dB(A) during day and 60 dB(A) during night. Outdoor visibility is assessed with 2 sub-indicators related to visibility of noticeable sites and intervisibility of urban spaces. A first notation is assessing view quality of noticeable monument and places from indoor and from outdoor. Intervisibility is evaluated with view factor between sky and road, and view factor between sky and public spaces.

Finally, sunshine is characterized in intensity and in variability. Intensity is given by relative solar radiation received by public spaces, façades and roofs. Relative global solar radiation is solar radiation received by the studied surface which is divided by the maximum solar radiation received in the district. Global solar radiation corresponds to the sum of diffuse, direct and reflected solar radiation. Variability is assessed by means of relative standard deviation of global solar radiation received on 4 distinct orientations of buildings' façades.

4. APPLICATION

Focusing on the case of an urban planning operation in a district of La Rochelle (France), a project called “Espaces gare” concerns planning of 3 districts near the train station. We are working for the project manager, with the urban planner and local authorities, to offer planning decision aid. This section introduces a study concerning the district located at the east of the train station. This partnership has lead to the application of our method and to return on experience.

4.1 Setting of the project's alternatives

The studied alternatives, respectively called “July” and “September”, correspond to the al-
ternatives proposed in July 2005 and September 2005 by the urban planner AREP. Previous versions have not been studied because they haven’t been approved by local authorities. Both alternatives concern the same total habitable area of 20 000 square meters; the project manager requires this condition mostly for economic reasons. The district is delimited on the north by a road and on the south by railways. Concerning "July" alternative presented Figure 3, the urban planner proposes the construction of 22 buildings with height between 12 and 15 meters (each floor height is 3 meters).

There are 3 gardens in the core of the district and buildings' implantation aims to protect outdoor spaces from the acoustical noise of the road and the railways. "September" alternative is presented Figure 4: it concerns the construction of 12 buildings for the same total habitable area.

All buildings, except number 1, have same height of 12 meters. Moreover, in this alternative, the urban planner increases green surface which covers now the whole district. Major differences between alternatives concern height of buildings, surface allocated to gardens and ratios length to width.

4.2 Hypothesis and assessment
Considering district project's phase, few precise and definitive data are available regarding the composition of buildings' envelope. The main aim of the comparison method is to help optimizing implantation of buildings, choices of buildings' shapes, allocation of indoor spaces (housing, office, store, etc.) and localisation of public spaces such as green spaces. These choices will affect all indicators. Numerous hypotheses are required: choices are based on experience from previous studies and on measurements or computation based on the literature. Hypotheses are identical for each alternative in order to reduce importance of estimated data. As far as the project will progress, less hypotheses will be necessary and indicators will be assessed more precisely. Hypotheses concern various aspects: sunshine, energetic, life cycle analysis and acoustic; they are described and justified in Cherqui (2005).

4.3 Indicators assessment for each alternative
First of all, in Figure 5, we present indicators'
values which have been assessed for both alternative of the project introduced above. This table summarizes results concerning indicators; in order to facilitate the comparison, Figure 6 presents an Amoeba diagram of the indicators.

Considering the case of study, September alternative offers several improvements compare to July alternative. However, there is no major difference for some indicators, because there is no radical modification in buildings' implantation or shape between both alternatives. These results tend to demonstrate stability of simulations. September alternative will be preferred principally due to improvements in outdoor visibility and natural lightning. This choice is confirmed with studies related to others objectives (Cherqui, 2005).

Through confrontation of our method with a case study, we have shown that all indicators can be quantified, represented and they conduct to assessment of a district.

5. CONCLUSIONS AND PERSPECTIVES

Urban planning alternatives' comparison is feasible and gives valuable results. The method is operational. Nevertheless, our method required resources in time and persons in order to use computer codes.

The developed tool offers a useful mean to compare alternatives of a district planning project; user can interact with the instantaneous visualization of change on Amoeba diagram. List of indicators can be modified and user is free to choose to calculus method, depending on a specific project.

This work opens new perspectives: definition of new indicators to offer exhaustive assessment, application on other case study to benefit from return of experience and simplification of calculation of indicators in order to save time.

REFERENCES


art report, CRISP project report.


