Assessing urban sustainability: microclimate and design qualities of a new development

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ABSTRACT: Links between urban design qualities and microclimate conditions, combined with environmental impact and user responses, were identified In a previous article, showing the implications of the urban transformation process in the context of globalisation. This paper presents the results of applying environmental and sustainability assessment criteria to a new urban project in Puerto Madero, the dockland area under revitalisation process, close to the centre of Buenos Aires. The mix use development consists of three city blocks with views to the old port, and includes commercial activities and exhibition hall as well as residential accommodation. Qualities of urban design related to urban activities and the potential to attract users are relevant factors to overcome the conventional 'business as usual' character of the surrounding Puerto Madero development. The specific qualities, objective assessment criteria and ranking of each quality for each city block are presented showing favourable results, when compared to typical development. For this purpose, environmental studies to predict microclimate conditions and user response were carried out with models in the laboratory using wind tunnel and solar simulator. The assessment shows that the urban design qualities of permeability, vitality, variety, legibility and robustness, related to microclimatic qualities, contribute to the social, economic and environmental sustainability of the development. An important innovation in this case is the introduction of these factors in the practice of environmental impact assessment, required by the municipal legislation. The application of this approach demonstrates the value of objective criteria and physical simulation techniques to assess new urban projects.

Keywords: Urban design qualities, urban development, sustainability, microclimate, environmental assessment.

1. INTRODUCTION

In order to evaluate and qualify urban spaces as 'sustainable', a method to establish a set of design qualities is required in order to ensure effective and appropriate use and potential to attract users as well as providing lasting functionality over time. The series of urban design qualities proposed by Bentley et al in 1985 [1] refer to aspects associated with successful and responsive environments, generally accepted and intensively used by the public.

The five basic urban qualities proposed by these authors, 'permeability', 'vitality', 'variety', 'legibility' and 'robustness', have been shown to relate to the microclimate quality of outdoor spaces [2] as well as the environmental, social and economic sustainability.

This paper presents the definition and description of the urban qualities with a scale of evaluation applied to a major urban project in Buenos Aires, and shows a practical application of the scales included in the environmental evaluation for municipal presentation procedures. In order to test the technique, it is applied to a proposed development, in addition to the evaluation of existing urban design situations, undertaken in previous studies [3]. The urban design qualities for a new development in the Madero Port area of Buenos Aires is evaluated and compared with the qualities of adjacent new areas and traditional sectors of the central area of the city.

It is shown then that this evaluation technique can be used to provide design guidance as well as to evaluate urban projects, based on a ranking scale.

2. URBAN DESIGN QUALITIES

This section presents a description of the five urban qualities and a table to select the level of each quality according to the characteristics of the urban situation, as these are relative qualities depending on typical conditions of the urban tissue. In much of Latin America, the standard grid-iron city pattern introduced from the start of the colonial period provides a base for the typical physical urban sub-division.

2.1. Permeability

This quality implies open connections within the urban tissue or spaces, as well as links to the surroundings, accommodating different access modes according to the size and disposition of the component elements. The most important aspect of this quality is the capacity to allow freedom of choice and selection of alternative circulation routes, responding to the spatial democratisation [1].

Through routes and alternative circulation patterns support the subjective perception of facilitating pedestrian and vehicular circulation, while restricted access implies limited use of the urban space.

It could be argued that the possibility to reach a space does not necessarily mean that it is permeable, democratic or sustainable, showing the need to consider and balance all the urban qualities in an integrated approach. Table 1 shows the scale used to assess the degree of permeability of an urban project, public space or small neighbourhood, based on [3].

It is also important to distinguish between visual permeability and physical permeability. Open railings allow visual continuity of urban space without access, while private spaces allowing public access can improve permeability, though limited opening times, gates that are locked at night and security at entrances will inevitable reduce this quality [4].

Permeability can also be related to urban microclimate and protection from wind or access to breeze, as physical permeability is related to air movement.

Table 1. Scale of 'permeability'.

Level	Category	Definition
-2	Lack of permeability	Urban sectors with routes limited by railways or other urban barriers, very large city blocks.
-1	Limited permeability	Large city blocks, sub-divisions and plots with building complexes without through routes.
0	Normal	Typical city blocks (of about 100 m x 100 m for most cities of Argentina) without galleries, passages or other through routes.
+1	Permeable	Smaller city blocks or standard city blocks with pedestrian routes through the centre of the block.
+2	Very permeable	City block with various alternative through routes or open squares with open perimeter.

2.2. Vitality.

This quality can be interpreted as the potential offered by urban spaces to establish social contact, promote interaction between users and achieve a high intensity of activities carried out within the spaces. This is largely achieved by the design of urban spaces and the encouragement of 'active borders' of the public space, open throughout the day, which is also related to the number and frequency of entrances and the visual contact between indoor and outdoor spaces [1].

In warmer climates, the intensity of use of public spaces throughout the day and into the evening will contribute to security and the quality of vitality [6].

Table 2 shows the scale of vitality adopted for evaluating this quality in Buenos Aires, applied to public urban spaces. The high levels of activity within buildings, such as shopping centres, do not contribute to urban vitality in the same way as the traditional shopping street.

Vitality also depends on the creation of attractive urban microclimates, where variety is required to provide areas of sun and shade, access to breeze and wind protection, which is strongly related to the design of urban spaces.

Table 2. Scale of 'vitality'.

Level	Category	Definition
-2	Lack of vitality	Notable lack of activity in urban spaces, very limited number of entrances, land uses that discourage pedestrian movement.
-1	Limited vitality	Limited street activity, limited number of entrances, activities and land use that does not attract users.
0	Normal	Normal urban street activity, for example medium density residential areas with normal number of entrances.
+1	Moderate vitality	Greater level of activity than the urban average, with activities that attract pedestrians.
+2	High Vitality	Lively areas with large number of pedestrians and constant activity throughout the day.

2.3. Variety.

This quality refers to the capacity to accommodate and encourage complementary urban activities, with mixed uses. This variety will also contribute to vitality and the continuity of different uses over the day. Single use urban areas will attract a limited and specific public as well as limiting activity to specific hours of the day. The mixture of residential, commercial and other public activities will allow a continuity of activity over time. Additionally, Murrain [4] considers that 'concentration' and 'proximity' are two complementary conditions of this quality. Table 3 shows the evaluation criteria applied in this case.

Table 3. Scale of 'variety'.

Level	Category	Definition
-2	Lack of variety	Limited land uses and/or planning restrictions. Large buildings with single uses or groups of buildings with the same use.
-1	Limited variety	Scarce variation of uses and number of building types, restricting potential activities.
0	Normal	Normal variation of building types and range of urban activities within them.
+1	Moderate variety	Greater than average range of uses with a variety of building types and uses.
+2	Ample variety	Great variety of uses, different building types and complementary activities.

As in the previous qualities, variety is achieved by a combination of appropriate and mixed building types, permitted urban land uses and the variety of activities actually found in an urban sector.

2.4. Legibility.

This quality promotes the use of urban design at all scales to provide a clear understanding of the relationship between urban spaces, the ability to 'read' the routes and links through areas of the city and build a clear mental image of the urban structure.

This quality incorporates the visual perception of particular structures, following the argument that this helps to understand urban space and the way to orientate oneself in it. At the same time, legibility expresses identity and explains the relationship between functions and spatial relationships of the built environment. It is understood that legibility of the urban space complements and balances the previous quality of variety, showing the capacity to promote the appropriation of urban spaces through the rapid perception and comprehension of spatial situations.

The scale of legibility qualities is shown in Table 4, based on two urban attributes: landmarks and elements to aid visual orientation and the ability to understand the structure of the urban tissue itself.

This quality is clearly linked to permeability and variety, as an intricate maze of narrow streets may be difficult to understand though easy to walk through, and spatial variety may produce visual confusion, limiting legibility.

Table 4. Scale of 'legibility'.

Level	Category	Definition
-2	Lack of legibility	Urban structure difficult to understand, with lack of elements to provide visual orientation. Lack of identity.
-1	Low legibility	Lack of clarity in the urban structure, few landmarks or elements to aid orientation.
0	Normal	Normal urban structure and street pattern, without notable spatial identity.
+1	Moderate legibility	Easy understanding of the street pattern, with clear spatial identity.
+2	High legibility	Easy understanding of the street pattern and urban structure, with elements to aid the recognition of uses and orientate movement.

2.5. Robustness.

This quality is directly linked with the concept of sustainability; Murrain [7] makes reference to a 'robust building typology' in the urban fabric that ensures an adequate combination and variety of uses in each moment of time and over time, as well as responding to the efficient use of resources. This establishes links with the qualities considered previously. Robustness requires the ability of areas to accommodate different and changing uses over time, while responding to the range of requirements that arise form social transformation and technological development, contributing to the flexible adaptation to new functions

It is this quality that allows the useful life of buildings and urban sectors to be effectively extended. Although the potential capacity to modify uses will depend on planning legislation and the effectiveness of controls, it is important to recognise the specific limitations and opportunities available in different social and cultural contexts.

Table 5 shows the scale of robustness developed for Buenos Aires. Again, there is a clear link between variety and robustness as greater variety in building types and plot sizes offer greater opportunities to adapt to changing situations over time.

Table 5. Scale of 'robustness'.

Level	Category	Definition
-2	Lack of robustness	Very limited potential to adapt to changes or new uses, rigid subdivisions and lack of flexibility in building design.
-1	Limited robustness	Limited adaptability of the urban tissue, buildings with limited flexibility and variety.
0	Normal robustness	Average capacity of adaptation to changes with low potential to allow modifications of urban structure and building types.
+1	Moderate robustness	Better than average possibilities of change and development over time.
+2	High robustness	High potential to adapt to change flexible buildings and urban structure that be maintained over time.

3. DEVELOPING LINKS

3.1 Introduction

Using this frame of reference with scales of urban qualities, links were established between different aspects of the urban tissue, combining visual, spatial, social, economic and cultural potentiality.

Furthermore, it was then also possible to establish links between the urban qualities and microclimate created and modified by the spatial city structure. Both are in turn related to the potential to promote and encourage urban sustainability.

As these qualities are relative and subjective, rather than absolute and objective, the ranking therefore depend on an understanding of the cultural and environmental conditions found in each urban situation. In this assessment of urban qualities, the subjective scale is defined with the interpretation of values, together with the idiosyncrasies and customs of the specific situation studied in the city of Buenos Aires.

'Vitality', a typical quality of the centre of large cities, may also be found in small villages, although the type, intensity and character of the activities under study may vary. Even with the same scale, radical differences can be identified in cultures and countries.

'Permeability', a quality also closely related to the urban scale, may have a very different value in the regular and continuous grid pattern of Buenos Aires compared with the central sectors of Oxford with a roman and medieval origin.

The concept of urban design qualities as presented here, originally developed in Oxford, is applied here to a new development close to the centre of Buenos Aires.

As noted in the previous section of the paper, it is clear that the qualities are closely linked to each other and therefore need to be applied in an integral and comprehensive manner to achieve positive and effective results.

They all respond to requirements of sustainability of the built environment while allowing the integration of climate factors, a relevant aspect that is developed in the following section. Both quality of urban space and microclimate conditions can promote or discourage pedestrian activity and the intensity of urban space usage [8].

Table 6. Quality of urban design and quality of urban sustainability.

Quality [1]	**Urban design quality**	**Sustainable urban quality**
Permeability	Functional and visual connections in the urban tissue. Choice of alternative routes	Access to renewable resources of sun breeze and daylight. Access to promote social participation.
Vitality	Location and extent of active borders Frequency of entrances and indoor – outdoor relationship.	Social: Improve the quality of life conservation of cultural and social heritage Economic: promote commercial activity and exchange.
Variety	Variation of complementary uses day and night, indoors and outdoors.	Environmental: conservation of diversity. Social: inclusion of different social sectors.
Legibility	Comprehension of the urban structure and layout, relation with the city, visual identity, ease of identifying routes, activities and movement.	Social organization: promote self determination and appropriation of urban space, favour social responsibility participation and integration.
Robustness	Flexibility, ability to accept different uses and activities over time.	Flexible development, to favour change, renovation, reuse, revitalization and recycling.

3.2. Linking urban design quality, sustainability and microclimate.

The qualities of urban design defined in section 2 of the paper permeability, vitality, variety, legibility y robustness, maintain a close relation with the principles and requirements of urban sustainability as table 6 shows,

It is important to note that the qualities are related to environmental factors, influencing the capacity of urban spaces to provide adequate comfort.

Two factors are considered, sun and wind with both positive and negative impacts on urban microclimate as shown in table 7.

Table 7. Quality of urban design and microclimate.

Quality [1]	**Urban design quality.**	**Microclimatic quality.**
Permeability	Functional and visual connections in the urban tissue Choice of alternative routes	Access to renewable resources of sun, breeze and daylight. Lack of protection from wind and shade.
Vitality	Location and extent of active borders Frequency of entrances and indoor – outdoor relationship.	Environmental conditions that favour outdoor activities with a stimulating microclimate.
Variety	Variation of complementary uses day and night, indoors and outdoors.	Variety of microclimate conditions and opportunities to choose alternative outdoor environments for urban use.
Legibility	Comprehension of the urban structure and layout, relation with the city, visual identity, ease of identifying routes, activities and movement.	Ease of understanding microclimate potential and possibilities to achieve outdoor comfort and acceptance to perform open air activities.
Robustness	Flexibility, ability to accept different users and activities over time.	Possibilities to adapt, correct or modify environmental conditions in urban spaces.

4. CASE STUDY

The development of a large mixed use urban project in Madero Port, a major revitalisation area of Buenos Aires, provides the opportunity to test the evaluation system and assessment procedure of design qualities and their relation with microclimate and sustainability requirements.

Figure 1 shows a general view of the project with the model used for wind and solar access studies. This mixed use project 'El Aleph', designed by Norman Foster & Partners in London and Berdichevsky & Cherny Architects in Buenos Aires, includes residential accommodation, commercial facilities and a convention and cultural centre in three city blocks. This project is compared with the surrounding development and the development in the centre of Buenos Aires.

Table 8. The urban design qualities of the three new blocks.

Quality	South	Central	North
Permeability	0	+2	+2
Vitality	0	+2	+1
Variety	0	+1	+1
Legibility	+1	+2	+1
Robustness	0	0	0
Total	+0,2	+1,2	+1

Table 9. The average score for the urban design qualities of El Aleph, compared with the surrounding area and the city centre.

Quality	El Aleph	Madero	Centre
Permeability	+1,3	0	0
Vitality	+1,3	0	+2
Variety	+0,7	0	+2
Legibility	+1,3	0	+1
Robustness	0	0	+1
Total	+0,9	0.0	+1,2

Tables 8 and 9 show that the proposed development achieves a higher qualification than the conventional development in Madero Port, principally due to the high 'permeability', with various pedestrian routes and spaces open to the public in the centre of the blocks, as well as a higher 'legibility' than conventional adjacent urban development. The proposed incorporation of mixed uses improves variety and vitality, however lower than the central area of the city core.

The offer of microclimatic control is also better in the new project than in the surrounding urban development. This is due to the larger proportion of urban space open to the public and a number of design resources incorporated in the project, such as:

- The roof over the central 'plaza' provides partial sun and rain protection.
- Planting in the 'plaza' and centre of the northern block is a vital natural resource to provide shade and wind protection for pedestrians.
- The 'recova' the covered pedestrian sidewalk circulation has rain and sun protection.

These microclimate qualities were evaluated by laboratory studies with shadow and wind tunnel tests using a scale model as well as simulations with virtual models. A particular microclimatic quality, considered in the environmental assessment, is the variety of alternative conditions offered to the users of public spaces. The balconies and entrance galleries also provide a wider range of private outdoor conditions than that found in the adjacent conventional urban developments.

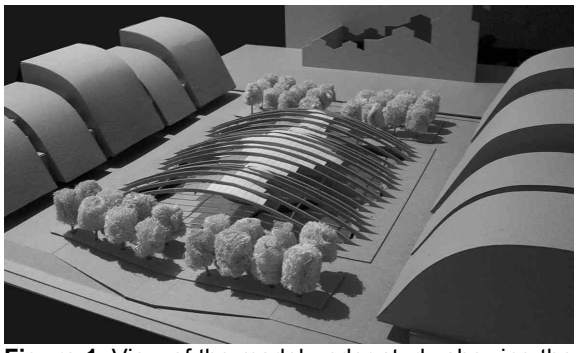

Figure 1. View of the model under study showing the central sector with the 'plaza' of 'El Aleph' urban project in Madero Port, Buenos Aires.

Table 10. Evaluation of urban microclimatic quality.

	El Aleph	Madero	Centre
Winter sun	+1	+0,5	0
Summer shade	+0,5	-0,5	+1
Wind protection	+0,5	-0,5	+1
Summer breeze	+0,5	+0,5	0
Total	+0,6	0	+0,5

Table 10 shows the results of the microclimate evaluation, using the same 5 point scale from -2, very poor, to +2, very favourable. The wide streets of Puerto Madero offer less protection from summer sun or winter wind than the typical streets of the central area of the city. The 'plaza' and centre of the southern block offer relatively protected public circulation spaces providing a range of alternative microclimates, within short walking distances, a positive condition.

5. CONCLUSIONS

The case study confirms that urban sustainability depends on economic, social and environmental factors. While the indoor activities and environmental conditions are fundamental, the conditions in outdoor spaces also contribute to the sustainability process.

The method presented in this paper allows the combined assessment of urban design quality and environmental factors directly. It is shown that these qualities are closely related to built form and to the microclimate conditions created in outdoor spaces. The microclimate evaluation and the assessment of urban design quality was successfully applied to an urban project in a regeneration area of Buenos Aires. The results confirm the interrelation between physical form, economic development, social behaviour and environmental conditions in public urban spaces.

Improvement of environmental conditions in urban spaces requires complementary economic and social qualities to ensure successful use over time. The method presented provides an assessment tool for evaluation and a guide to designers in the process of promoting sustainability in the built environment.

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