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The ecodesign and planning of sustainable neighbourhoods: the Vallbona case study (Barcelona)

El ecodiseño y planeamiento de barrios sostenibles: el caso de estudio de Vallbona (Barcelona)

R. Farreny [*a,b], J. Oliver-Solà [a,b], M. Montlleó [c], E. Escribà [c], X. Gabarrell [a,d], J. Rieradevall [a,d]

SUMMARY

Global sustainability is increasingly an issue of urban sustainability, being essential to encourage more benign trajectories of urbanisation. For this, there is need for a framework that could aid in the process of designing and redesigning (retrofitting) cities. The aim of this paper is to present and describe the methodology of urban ecodesign, which is characterized by a systematic incorporation of environmental life cycle considerations into the design of urban systems. The paper presents a case study of neighbourhood ecodesign from the city of Barcelona (Vallbona neighbourhood). This practical experience shows that the inclusion of sustainability criteria at an early stage of the design and planning of urban systems is the best strategy for environmental protection.In addition; a methodological framework is described in order to provide planners with a structured way of designing urban settlements so as to move towards sustainable urban environments.

113-121

Keywords: ecodesign, urban sustainability, neighbourhood, cities.

RESUMEN

La sostenibilidad global es cada vez más un tema de sostenibilidad urbana. Por este motivo, es necesario un marco de trabajo que pueda ayudar en el proceso de diseño y rediseño (rehabilitación) de nuestras ciudades. El objetivo de este trabajo es presentar y describir la metodología de ecodiseño adaptada a los entornos urbanos, la cual se caracteriza por la incorporación sistemática de las consideraciones ambientales a lo largo de su ciclo de vida. El documento presenta un caso de estudio de ecodiseño del barrio de Vallbona (Barcelona). Esta experiencia demuestra que la inclusión de criterios de sostenibilidad en las etapas iniciales de diseño y planificación de los sistemas urbanos es la mejor estrategia para la prevención ambiental. Además, se presenta un marco metodológico con el fin de proporcionar a los planificadores una forma estructurada de diseño de los asentamientos urbanos que les permita avanzar hacia entornos urbanos más sostenibles.

Palabras clave: *ecodiseño, sostenibilidad urbana, barrio, ciudades.*

(a) Institute of Environmental Science and Technology (ICTA).
Universitat Autònoma de Barcelona (UAB). 08193 Bellaterra, Barcelona (España).
(b) Inèdit Innovació SL. UAB Research Park. Barcelona (España).
(c) Barcelona Regional SA. Barcelona (España).
(d) Chemical Engineering Department, XRB. Universitat Autònoma de Barcelona (UAB). Barcelona (España).
(*) Persona de contacto / *Corresponding author*: ramon@ineditinnova.com (R. Farreny).

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INTRODUCTION

Urban areas and environments are expanding worldwide as statistics for urban population share reach figures of 70% in Europe, America and Oceania and even 50% on a global level (1). This unprecedented growth in urbanisation will lead to important but as of yet poorly understood impacts on the Earth's environment (2). Despite representing only 2.7% of the world's surface area (3), the world's cities are responsible for 75% of the world's energy consumption and 80% of greenhouse gas emissions (4). Therefore, global sustainability is increasingly an issue of urban sustainability, being essential to encourage more benign trajectories of urbanisation.

Sustainable planning implies that environmental goals have the same importance as traditional social and economic goals. Therefore, the goal of sustainability in urban areas could be defined as a reduction in their use of natural resources and waste production, while simultaneously improving livability in order to better fit within the capacities of local, regional and global ecosystems in a framework of social equity and welfare (5).
The design of sustainable urban areas is not a simple task since a universal model for a sustainable city cannot be found, nor implemented (6). In addition, there is a lack of tools and approaches that could aid in the process of both urban ecodesign and retrofit.

In the construction of new urban developments, planners are able to act form the early stages of design. By doing so, it is possible to condition the environmental, economic and social performance of urban systems, and to propose more ambitious strategies (e.g. integrating agriculture and green spaces into the city). Any neighbourhood designed to be correctly integrated with the environmental characteristics of its surroundings will certainly be more efficient and sustainable than another that has not been designed taking these criteria into account (7).

By contrast, working with existing urban areas reduces the possibilities of action. Thus, improving their environmental/economic performance is more challenging since projects involving retrofit actions may have lacked environmental protection at the design stage. The fact that Europe is an old continent with a lot of retrofit to undergo and its limited population growth indicates that efforts will need to be directed mostly towards retrofitting (instead of constructing new developments). This may suppose a constraint to the implementation of urban sustainability in our continent, and entails that the possibilities of achieving urban sustainability in existing areas will greatly depend on past decisions beyond the reach of current planners.

Tools for urban sustainability

During the last years, there have been many efforts towards more sustainable urbanization patterns (for instance, the China Sustainable Cities Program or the World Bank Eco²Cities Program (8)). In addition, many cities have applied environmental assessment tools such as environmental audits or planning tools such as Agenda 21. However, there are few experiences on the use of more innovative tools such as Life Cycle Assessment or the establishment of ecodesign principles as a core issue in urban planning and retrofitting. Despite this, these tools are emerging with great interest at the urban level. A reason for this is that there is need for a framework that could aid in the process of designing and redesigning (retrofitting) cities. In this context, the methodology of ecodesign of products, adapted to the broader urban level, appears to be useful, since it considered one of the key tools in the move towards a more sustainable city (7).

Aim of the paper

The aim of this paper is to present and describe the methodology of urban ecodesign by means of a case study from a new neighbourhood that will be built in the city of Barcelona.

CASE STUDY NEIGHBOURHOOD

The city of Barcelona is located on the north-eastern coast of Spain with a population of approximately 1.6 million inhabitants and an area of 100 km^2. It has a Mediterranean climate with average rainfall of 600 mm and an average annual temperature of 15.5ºC. Currently, environmental criteria are becoming more and more important in the planning process of the city, including issues of water consumption, waste, greenhouse gas emissions, and efficient use of energy (9). Besides, the Barcelona city council has signed the Covenant of Mayors, a commitment to go beyond the objectives of the European Union energy policy in terms of reduction in carbon dioxide (CO_2) emissions, and reduce its CO_2 emissions by 20% by 2020 (10).

In this context, the city council of Barcelona approved, in October 2008, to establish sustainability as the driving force for the planning of the last section of its territory to be urbanised (11). This new neighbourhood will be situated in an area called Vallbona located in the northern part of the city (Figure 1), which occupies a developable area of 32.6 Ha. This area was not been urbanized up to the moment due to its particular characteristics (it was mostly zoned as mobility systems (52.3% railway, 12.5% roads), but also facilities (local 12.5%, metropolitan 14.4%), free spaces (parks and gardens 4.9%) and

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1. Location and aerial photograph of the Vallbona neighbourhood (12).

other (general systems protection 3.4%) and because it has been faithful to its traditional agricultural uses).

These factors have resulted in the fact that Vallbona presently lacks urban continuity and presents many structural deficiencies as well as isolation from the rest of the city. The area is almost completely surrounded by natural barriers (the Besós river on one side) and artificial barriers (a dense network of roads, highways and railways). This peripheric and isolated location gives Vallbona an autonomous semi-rural character, which is fostered by its traditional linkage with agriculture.

Next to the area that is going to be urbanized there are some constructions that currently gather about 800 inhabitants, concentrating low income citizenship, with high unemployment rates and relatively high crime rates. The origins of the settlements in the area go back to an urbanization process from the 1950s that was initially characterized by self-construction works. Basic services (water supply and sewage systems, public transportation) came about twenty years later. Later, in 1976, the General Metropolitan Plan of Barcelona was formulated, setting the prescriptions that have shaped the city during last decades, and that laid down the bases for the urbanization, renewal and retrofit of the area of Vallbona (12).

The future neighbourhood will host 2120 dwellings (with a floor area ratio of approximately 0.7) which will represent an important transformation for this area.

ECODESIGN METHODOLOGY AND RESULTS

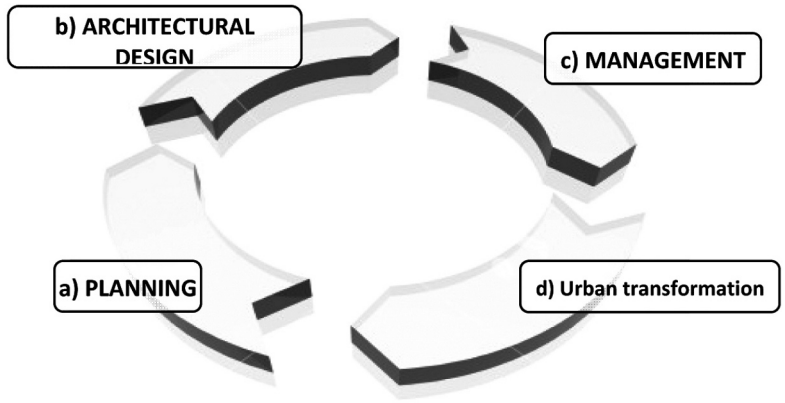
This section presents the methodology of ecodesign by describing its stages and their application in the case study neighbourhood.

Definition

The eco-design consists of the consideration of environmental criteria in the development of a product, without obviating other key aspects of design (costs, functionality, aesthetics, etc.); with the aim of using the minimum amount of resources and generating the minimum emissions along the life cycle of the product. Thus, it can be defined as "the systematic incorporation of life cycle considerations into the design of products, processes or services" (13). Actually, it is one of the most valid tools to reduce the inherent environmental burdens associated to products.
The benefits of ecodesign are many: reducing environmental impact, reducing costs, innovating, satisfying legal environmental requirements, increasing the quality of the product and improving the image of the neighbourhood and the whole municipality (14).

The life cycle approach

Ecodesign means that environmental aspects have been taken into account for decision-making along the neighbourhood design process, as an additional factor to the ones which have traditionally been considered (financial, social, political… aspects). The goal of ecodesign is to reduce the environmental impact of the neighbourhood along its whole life cycle. The life cycle of a neighbourhood (or a city) is here understood as all the stages for which it evolves, which includes (a) the planning stage, (b) the architectural design and construction stage, (c) the neighbourhood management stage and eventually (d) urban transformation (rebuilding the city) and revision of planning schemes (figure 2). By being able to act from the planning stage (a), there is large room for the achievement of high environmental standards in the eventual neighbourhood. However, in case



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2. Life cycle of an urban settlement.

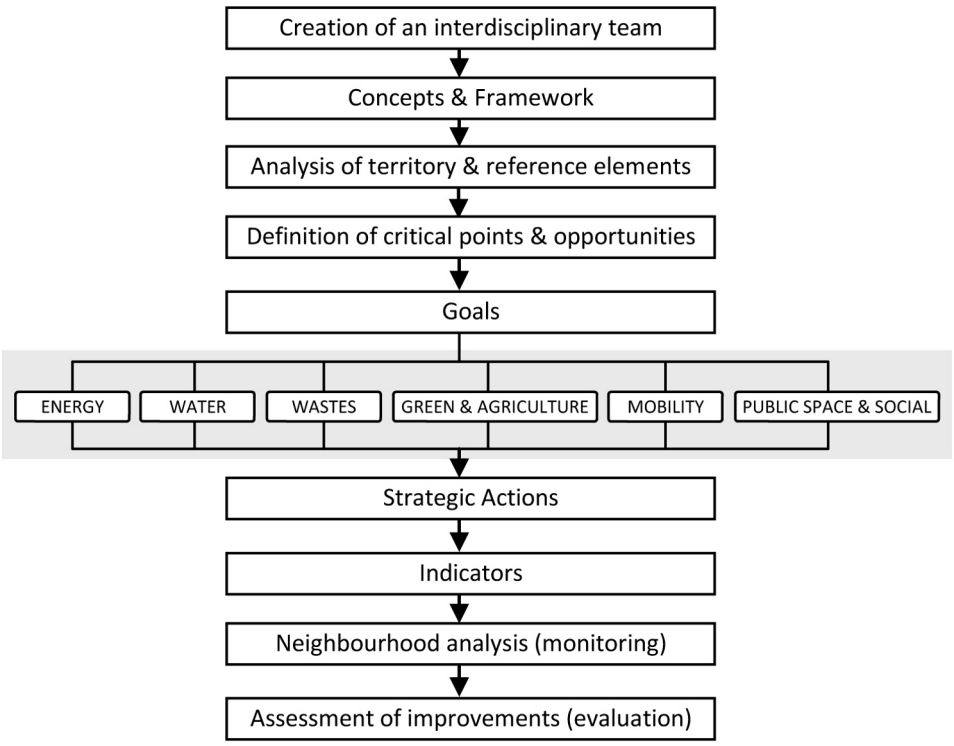
3. Diagram of the planning and ecodesign methodology applied at the neighbourhood scale in Vallbona (Barcelona, Spain).

of retrofitting, the challenge lies ahead on being only able to act from stage (d) of the life cycle of a neighbourhood, that is, urban transformation.

The life cycle approach at the design and planning level implies the recognition that each decision made in the early stages of planning has consequences (social, economic and environmental) on the following urban stages. Often these are not obvious or immediate and they are only observed when examining the complete life cycle of the neighbourhood. Through a life cycle approach, decisions can be made in a more deliberate and systematic way.

In the design of the Vallbona neighbourhood, environmental aspects have been incorporated since the conceptualization of the neighbourhood and considering the intrinsic determining factors of the area. These aspects have been developed for the first three stages (a, b, c) of the life cycle. However, it has to be stated that the set of strategic actions beyond the planning stage is just a list of recommendations, since the team was working on a planning proposal and not on concrete construction projects. Despite this, the aim is to set a basis for the professionals who are going to undergo the architectural design and construction and also the people responsible for the management of the neighbourhood. Once the planning stage is complete, the next stages - (b) and (c) - of the neighbourhood life cycle will take place, all of them circumscribed to the orientations and requirements stated earlier in the planning (a).

Figure 3 shows a diagram of the methodology followed throughout the design and planning process of Vallbona, that could be applied to the ecodesign of any other neighbourhhod.



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Step 1. Creation of an interdisciplinary team

The first step is to create an interdisciplinary design team, which is of great value and it is essential in urban planning. The design team should have sufficient understanding of sustainable design practices, constraints, existing conditions and specifications (15). Practical experiences, together with the rapid evolution of the sustainability science, provide planners with a knowledge body at their disposal. From these experiences, data and criteria may be obtained for the design of future neighbourhoods. The close collaboration between scholars and practitioners coproduces the necessary knowledge to harness science and technology for sustainability (16).

In Vallbona, the team was lead by Barcelona Regional (the agency for the development of urbanism and infrastructures in the Metropolitan Area of Barcelona; an entity with wide experience and proud of having a highly interdisciplinary team). Furthermore, a team of researchers from the Institute of Environmental Science and Technology at the UAB also participated in the work group. Their main goal was to reinforce the environmental approach of the planning and design, both in terms of methodology and concepts. All in all, a total of 23 professionals were directly involved in the definition, discussion and redaction of the proposal; and many other professionals were consulted and/or interviewed. The team exploited the synergies that were created among its members and their previous experiences in other town-planning projects and in the field of environmental analysis.

Step 2. Concepts and framework

Once such an interdisciplinary team had been formed, several sessions were planned to debate and decide how the neighbourhood should be and which the best strategies to achieve it were. A session was dedicated to general concepts about urban sustainability and sustainable neighbourhoods in order to set a framework for debate and decision-making for Vallbona. Here, the definition of 'sustainable neighbourhood' was defined and agreed upon, in order to move from a political wish to a specific result.

A sustainable neighbourhood was defined by the interdisciplinary team as an urban settlement that is adapted to the local environmental characteristics and makes an efficient use of resources (first and foremost local), minimises its emissions, and shows an increase in quality of life and respect towards the natural environment, so it can better fit within the capacities of the local, regional and global ecosystems.

Together with this definition, the team debated and agreed upon several key concepts whose fulfilment was, in our opinion, necessary for the achievement of the sustainable neighbourhood:

- Circular metabolic flows and trend towards self-sufficiency (trying to close the flows of materials, water, energy, food…, developing synergies within the neighbourhood and with the surrounding areas, environmental protection…).
- Neighbourhood for people (streets for pedestrians, healthy environment, environmental education, participative processes…).
- Mixticity of land uses (agriculture as an urban land use, vertical integration of land uses, multifunctionality of spaces…).
- Biodiversity (protection of characteristic local elements, creation of new biotopes related to water management and/or to buildings…).

Step 3. Analysis of the territory and of reference elements. Definition of critical points and opportunities

The task was to undergo an environmental, social and financial analysis and diagnosis of the territory where the neighbourhood was going to be located, since it is clear that each location has to take into account its site-specific characteristics and given conditions (15). Then, the team conducted an analysis of some reference elements (other neighbourhoods in the metropolitan area and in other regions) in order to detect their critical points but also their strengths and opportunities.

Step 4. Setting goals

Next, several thematic sessions were carried out in order to set goals for each of the following topics: energy, water, wastes, green and agricultural areas, mobility and transportation, public space and social environment. For each one, the set of goals was proposed having as an indication the analysis and diagnosis for the reference elements (step 3). Ideally, the goals should be set in quantitative terms, which would facilitate to monitor its achievement.

Step 5. Strategic actions

Later, the strategic actions aimed at the achievement of the goals were defined for each topic. Strategic actions can arise from the experiences of the working team and from the analysis of reference elements and territory. These actions were debated within the working team and with the policy makers, and were tested for economic viability in terms of cost benefit analyses. The actions

take into account the different stages that shape the neighbourhood through its life cycle. In order to define the strategic actions, it is necessary to have access to information in order to aid in the decision-making process. In this sense, it is necessary to improve the access to environmental, economic and social data, in order to manage global environmental threats under the "life-cycle thinking" approach.

In Vallbona, a total of 68 strategic actions were defined for each topic, taking into account the different stages that shape the neighbourhood through the life cycle of a city. However, it was strongly believed that it was necessary to focus most of our attention on certain specific actions which could have the highest positive impact on the neighbourhood. Therefore, from the set of actions, all of them important, there were 5 which were highlighted as particularly important in order to assure the development of the neighbourhood under sustainability criteria. These actions were:

- To minimize the energy demand of buildings. There is large room for this at the planning level through the layout of buildings and blocks in order to take advantage of solar passive architecture and natural ventilation systems. It is also possible to set a minimum requirement for energy efficiency in buildings.
- To use local renewable energy sources and a district heating network. The intense solar radiation enables us to efficiently introduce thermal and photovoltaic solar systems. Furthermore, a district heating network may take advantage of thermal solar energy and cover most heating, ventilation and air conditioning needs.
- To maintain as much as possible the agricultural mosaic of the area. The area under planning hosts one of the last pieces of agricultural land in the city, which has a great landscape value and represents a distinctive element of it.
- To diversify the water sources, adapting the quality of water to its uses. There are several potential water sources in the area (rainwater, groundwater, surface water, pipe water, grey and black waters …) which have to be efficiently managed and assigned to the most adequate use.
- Local resources manager. This last action, which is thought to be put in practice along the management stage of the neighbourhood, is a new concept. City management has become a complex undertaking because social-cultural, economic, environmental and institutional processes have become increasingly intertwined in cities (17). Therefore, there is a need for a resources manager who could proficiently handle local resources and manage the neighbourhoods' environmental facilities. This need has already been detected in the industrial sector as a key concept for its sustainable development (18), but it is rarely observed in neighbourhoods or cities. The resources manager could deal with local resources such as solar energy installations, public vegetable gardens, own water distribution systems (grey water, stormwater runoff…), organic wastes and composting… and could take care of environmental facilities such as common parking areas. This actor is essential for sustainable development since the holistic system approach to resource management is a must for the efficient use of resources. The local resources manager could be integrated at the neighbourhood or district level, since this represents an adequate scale for managing metabolic flows (17), and probably depending on the town council level.

Step 6. Indicators

Several indicators have been defined along the design process, in parallel to the definition of goals and strategic actions. A set of environmental indicators is necessary to visualise the path of the neighbourhood in order to determine its position compared to the strategy formulated and thereby enabling the diagnosis of the current status, but also the prognosis of the future situation (19).

The set of indicators is proposed as a framework for monitoring and evaluation (following steps of the methodology). This is important since it is necessary to include mechanisms that help follow up the implementation of the planning proposal and that take care of the operation and maintenance of the elements of the urban systems. Monitoring and evaluation are both tools which help us to know when something is not working, and when circumstances have changed. Thus, they are useful for decision making.

In Vallbona, a selection of 15 indicators was made, which endeavour to meet the following criteria: quantifiability, representativeness, low cost, homogeneous measure over time and clarity in the interpretation. Each indicator was described considering its definition, how its variables are defined, which is the desirable trend, calculation equation, data source and other complementary comments. The indicators are defined for the management stage, since most environmental and financial costs are related to the operation of the neighbourhood (often over 90 % of life cycle costs for typical infrastructures in cities are spent during operational maintenance and rehabilitation (8)).

Table 1 summarizes the goals, strategic actions and indicators for the case study neighbourhood. The list of strategic actions has been simplified for reasons of space. After the table, two of the indicators will be described in more detail as an example.

Indicator: Water Self-Sufficiency

It is desirable for any urban system not to depend too much on external water resources. This indicator measures the capacity of the neighbourhood to self-provide the water consumption it demands. It is calculated as the ratio between the local endogenous water resources consumption (groundwater and rainwater) to the total water consumption (including pipe water). The desired trend is to move towards 1, which would mean not depending on reticulated mains water.

Indicator: Local Food production

Urban agriculture is emerging as a strategy for urban sustainability since it presents many benefits: it creates occupation, reduces transportation demands and costs, enhances the links of people with nature, improves the quality of urban environments... This indicator evaluates the local food production in the agricultural areas of the neighbourhood, expressed in tones/year. As sub-indicators, it is also expressed in production per unit of area of agricultural land and per inhabitant.

Step 7. Neighbourhood analysis (monitoring) and assessment of improvements (evaluation)

After completing step 6, the planning proposal of the neighbourhood could be de-

Table 1
Summary of goals, strategic actions and indicators for the Vallbona neighbourhood

TOPIC	GOALS	STRATEGIC ACTIONS	INDICATORS
ENERGY	• To minimize energy demand per inhabitant in buildings • To use local renewable energies	• Passive saving measures: Orientation optimization (minimum 4 hours direct insolation/day in winter) • Natural ventilation • District heating • Efficient architecture	• Primary energy consumption • Renewables production • Equivalent CO2 emissions
WATER	• To diversify water sources, adequate water quality to its uses and use local water sources • To reduce consumption	• Separative sewer • Rainwater harvesting from roofs and non-trafficked areas • Irrigation with local river sources • Groundwater use • Greywater reuse	• Total pipe water consumption/ inhabitant • Water self-sufficiency
WASTES	• To maximize selective waste collection • To cover the manure demand of agricultural areas with local compost	• To compost organic waste within the neighbourhood • Waste collection at street level (not pneumatic)	• Urban solid wastes production • Selective collection of wastes
GREEN & AGRICULTURAL SPACES	• To preserve and foster local biodiversity • To maintain the agricultural mosaic as a distinctive landscape element • To foster the local river as a structural element • To design new green areas with environmentally-friendly criteria • Participative management of non-professional vegetable gardens	• Preservation of an irrigated agricultural plot of 2,3 Ha • To make compatible professional agriculture and social vegetable gardens • Xerogardening • Promoting green areas with sustainable criteria and aimed at preserving local biodiversity within the urban fabric	• Local food production • Bird biodiversity in green areas
MOBILITY	• To improve the connectivity with the surrounding areas • To rationalize the mobility flows • To recover the public space for people • To reduce private mobility	• New connections with the surrounding areas • To keep 75% of the road network for pedestrians • To foster bicycle use • To minimize public space devoted to parking • Improvement of the bus network	• Transportation modal split • Car sharing clients • Average time for several trips
PUBLIC SPACE AND SOCIAL ENVIRONMENT	• To minimize acoustic pollution • To assure the permeability of public spaces • To design public space in order to foster social relationships	• Installation of noise-reduction elements • To facilitate access to public transportation systems and to services through new accesses • New equipments so as to serve people's needs and to integrate the neighbourhood in the whole city	• Proximity to basic urban services • Ecodesigned urban furniture • Social participation

4. Virtual aerial image of the project (12).

fined. This planning proposal would then be subjected to political evaluation and public hearing and debate processes, and eventually, the political approval would take place. Then, the next stages of the life cycle (figure 2) would take place.

From the ecodesign process, a sustainable neighbourhood planning proposal was defined. Then, it was evaluated by the city council. This procedure resulted in feedback and, where necessary, the proposal was adapted. After this, a public hearing and debate process took place. Eventually, the city council passed an initial approval of the planning proposal in March 2009. After this initial approval, and once the indications from the implicated agents, objections and preceptive reports were considered, a provisional approval took place in February 2011 (pending of definitive approval in the coming months) (12).

Step 7 would start with the management stage (stage (c) in figure 2), once the neighbourhood is in operation. Then, it would consist of an analysis of the ecodesigned product, that is to say, the neighbourhood, with the aim of obtaining an environmental diagnosis of the neighbourhood. The systematic collection and analysis of information along the use stage of the neighbourhood (monitoring) can let decision makers know when things are going wrong. If done properly, it is an invaluable tool for good management, and it provides a useful base for comparison of actual project performance against the agreed goals and also against the reference elements (evaluation). Monitoring and evaluation are both tools which help to know when something is not working, and when circumstances have changed.

There are several methodologies and tools in order to undergo monitoring and evaluation, being one of them the monitoring and control of the set of indicators. Then, the follow-up of the set of indicators and its comparison with goals and reference elements would be useful. This process in Vallbona will have to wait until the neighbourhood becomes a reality and it is in operation.

DISCUSSION AND CONCLUSIONS

The ecodesign methodology has been applied to the design of a neighbourhood (a virtual aerial image of which is presented in figure 4). This process differs from a conventional urban design mostly due to the incorporation of environmental criteria along the whole

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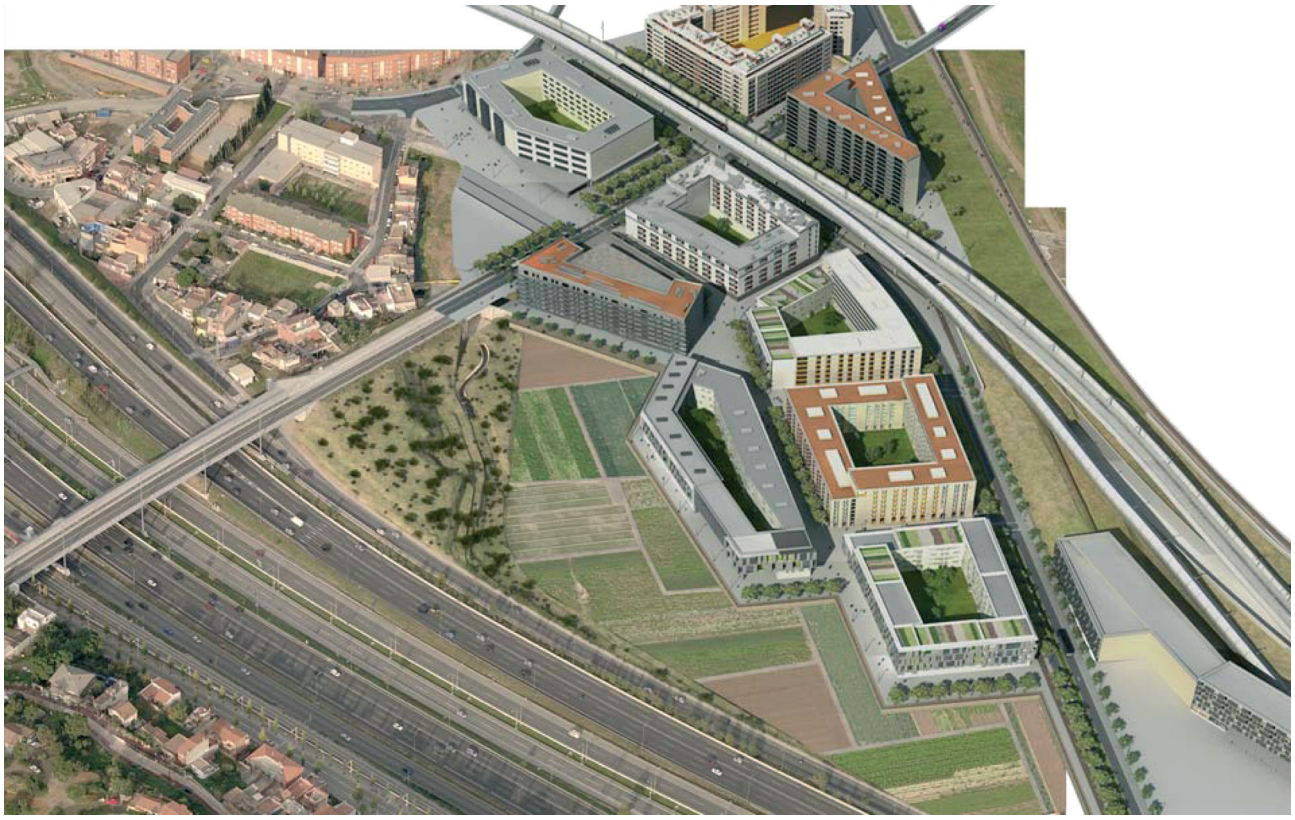

life cycle of the neighbourhood and the presence of such a highly interdisciplinary team. Among these aspects, the former is of particular relevance since the incorporation of the life cycle approach in the early design of a neighbourhood (from planning to architectural design and construction, to later management and followed by urban transformation) encourages environmental protection and guarantees the achievement of urban sustainability goals. Actually, the inclusion of sustainability criteria at an early stage of the design and planning of urban systems is the best strategy for environmental protection. This implies the recognition that each decision taken in the early stages of planning has consequences (social, economic and environmental) on the following urban stages along the life cycle of urban systems.

It must be kept in mind that the planning of a sustainable neighbourhood does not necessarily mean that the eventual neighbourhood will actually be sustainable. For this, it is necessary to establish monitoring and control mechanisms to make sure that the plan is correctly implemented and results in a sustainable neighbourhood and, when necessary, implement appropriate strategies and corrective measures (e.g. education programs, efficiency in the use of resources). However, a good planning proposal is the basis for the achievement of the sustainability goals and, consequently, the environmental performance of the neighbourhood is expected to achieve high standards.

Furthermore, the planning process generally takes place in a complex institutional frame with a large number of public and private actors, each of them with their own interests and responsibilities. Therefore, the ecodesigned proposal may find obstacles to its approval. Besides this, the local context and given conditions are determinant for the successful achievement of the proposed goals.

In the case of Vallbona, the main obstacles were found to be related to regulatory determinants. The development of the neighbourhood was highly conditioned by its previous classification as a Strategic Residential Area under the auspices of the Catalan government in order to solve regional housing shortages (20). This constituted an important determining factor since it made certain compulsory specifications, such as the extent to which land use is mixed, heavily influenced by the need to provide housing. Therefore, this prevented a mixticity in land uses, which is considered to be an essential aspect for urban sustainability (17). Another important constraint was related to economic aspects, especially in the current context of economic crisis and public deficit. In this sense, economic criteria generally prevailed in front of environmental ones when taking some decisions. Besides, environmental externalities (that is to say, beneficial environmental effects that are not priced in the market and therefore are not economically compensated) were usually not accounted for, which eventually resulted in dismissing some environmental strategic actions.

On the other hand, other aspects favoured the development of a neighbourhood planning proposal with high environmental standards. Among these, it worth higlighting some territorial aspects, namely, the high urban density of the metropolitan region (which makes possible to reduce the transportation energy demand and to enhance social relationships), and the availability of natural resources (water, agricultural land, riparian forest, insolation).

From this, it becomes clear that the design of neighbourhoods in different locations will lead to different results, without the existence of a unique path to achieving urban sustainability or a uniform solution. In spite of this, the presented ecodesign methodology tries to bring light into this issue by providing planners with a structured way of designing urban settlements so as to move towards sustainable urban environments.

Future research will focus on the area of retrofit of existing urban areas. Important efforts need to be addressed into this direction, since many regions with existing consolidated urban areas (e.g. Europe) will need to redesign its urban environment in order to make a transition towards urban sustainability. With this purpose, the methodology of urban ecodesign presented so far can still be applied since it remains conceptually valid. However, it is expected that some obstacles may arise along the implementation of some concepts and strategies, since dealing with existing urban environments is much more complex than planning and constructing a greenfield development.

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REFERENCES

(1) United Nations. World Urbanization Prospects: *The 2007 Revision Population Database 2008*. Retrieved on February 2010 from: http://us-cdn.creamermedia.co.za/assets/articles/attachments/11764_prospects.pdf.

(2) Bettencourt, L. M. A. *et al.*: "Growth, innovation, scaling, and the pace of life in cities". *Proceedings of the National Academy of Sciences of the United States of America*, vol. 104, nº 17 (2007), pp. 7301-7306.

(3) United Nations. Urban population: *Development and the Environment. 2007*. Retrieved on May 2009 from: http://www.un.org/esa/population/publications/2007_PopDevt/Urban_2007.pdf.

(4) Ash, C. *et al.*: "Reimagining cities – Introduction". *Science*, vol. 319, nº 5864 (2008), pp. 739-739.

(5) Farreny, R.; Gabarrell, X.; Rieradevall, J.: "Energy intensity and greenhouse gas emission of a purchase in the retail park service sector: An integrative approach". *Energy Policy*, vol. 36, nº 6 (2008), pp. 1957-1968.

(6) Myllyla, S.; Kuvaja, K.: "Societal premises for sustainable development in large southern cities". *Global Environmental Change-Human and Policy Dimensions*, vol. 15, nº 3 (2005), pp. 224-237.

(7) Oliver Solà, J.: *Industrial Ecology as a discipline for the analysis and design of sustainable urban settlements*. Bellaterra (Barcelona): Universitat Autònoma de Barcelona; 2009.

(8) World Bank (2009): *Eco2Cities: Ecological Cities as Economic Cities,* http://www.worldbank.org/eco2 (last accessed August 2011).

(9) Carné and Ivancic: "The Barcelona City Model", in *World Cities and Urban Form. Fragmented, polycentric, sustainable?*, M. Jenks, D. Kozak and P. Takkanon (editors), 2008, Routledge: New York, p. 373.

(10) European Commission: *Covenant of Mayors. 2010.* Retrieved on October 2010 from http://www.eumayors.eu.

(11) Farreny, R.; Oliver-Solà, J.; Montlleó, M.; Escribà, E.; Gabarrell, X.; Rieradevall, J.: "Transition towards sustainable cities: opportunities, constraints, and strategies in planning. A neighbourhood ecodesign case study in Barcelona". *Environment and Planning A*, vol. 43 (2011), pp. 1118-1134.

(12) Ajuntament de Barcelona (2011): *Urbanisme i infraestructures.* http://w110.bcn.cat/portal/site/Urbanisme/.

(13) Tukker, A.; Haag, E.; Eder, P.: "Eco-design: the state of implementation in Europe - conclusions of a state of the art study for IPTS". *The Journal of Sustainable Product Design,* vol. 1 nº 3 (2000), pp. 147-161.

(14) IHOBE: *Manual práctico de ecodiseño*. Bilbao (Spain): 2000.

(15) Engel-Yan, J. *et al.*: "Toward sustainable neighbourhoods: the need to consider infrastructure interactions". *Canadian Journal of Civil Engineering*, vol. 32, nº 1 (2005), pp. 45-57.

(16) Clark, W. C.; Dickson, N. M.: "Sustainability science: The emerging research program". *Proceedings of the National Academy of Sciences of the United States of America*, vol. 100, nº 14 (2003), pp. 8059-8061.

(17) Farreny, R.: *Working towards strategies for urban sustainability.* PhD Thesis. Institute of Environmental Science and Technology. Universitat Autònoma de Barcelona, Barcelona, Spain.

(18) Roberts, B. H.: "The application of industrial ecology principles and planning guidelines for the development of eco-industrial parks: an Australian case study". *Journal of Cleaner Production*, vol. 12, nº 8-10 (2004), pp. 997-1010.

(19) Rotmans, J.; Van Asselt, M.; Vellinga, P.: "An integrated planning tool for sustainable cities". *Environmental Impact Assessment Review*, vol. 20, nº 3 (2000), pp. 265-276.

(20) Generalitat de Catalunya: *Decret llei 1/2007, de 16 d'octubre, de mesures urgents en matèria Urbanística. 2007*. Retrieved on January 2010 from: http://www.gencat.cat/diari/4990/07288186.htm.

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