

# Expansion of metropolitan areas, land use and sustainability indicators: the case of Valencia (Spain)

F. Gómez, L. Montero, V. De Vicente, A. Sequí & J. Langa  
*Architecture School, Polytechnic University of Valencia, Spain*

## Abstract

This work presents the last phase in an extensive piece of research done in the city of Valencia (Spain). The different parts of this research have been presented at different conferences: the overall study of the green zones in the city; a list of the green zones with the comfort afforded; formulation of some of the comfort indices used, modified for the city of Valencia; incidence of the study on the green zones in the city planning; list of the study of the green zones in the city with sustainability, through the sustainability indicators.

This starts by analyzing the application of the research as regards quantity and quality of green zones in the city, done in cooperation with the Green Plan for the city. Nevertheless, taking into account the way the city is growing, at the expense of the medium on which this is established, the market garden known as the *Huerta de Valencia*, which the Döbris report describes as the second richest in Europe, the absolute need to protect this from the invasion of the city and control and redirect Valencia's growth has been observed, if the aim is to reach sustainable planning.

This second phase takes into account the proposal put forward by the Valencian Authority, on the Plan for Protection of the Huerta, in line with the philosophy of European Territorial Strategy and the European Landscape Agreement.

*Keywords: green planning, indicators of sustainability, green zones, urban planning, Valencia (Spain).*



## 1 Introduction

Nowadays, cities are responsible for more than 75% of global pollution and use more than 70% of the energy consumed by mankind. The reality is that we are convinced that the urban areas in which we live are increasingly conflictive, unhealthy, unmanageable and, above all, are an enormous pressure on the environment. Therefore, it seems reasonable to think that the environmental problems must first and primarily be tackled and solved in cities.

Urban development has been in crisis for some time now and it is this profound city crisis, with its outstanding levels of deterioration, which has forced us to consider the value of the natural elements present in urban areas. In recent years, due to the fact that they are not found in the city, thousands of people rush each weekend to explore the habitats and natural spaces in their immediate surroundings. This is fundamentally because modern day civilization, especially the Western world, has made a clear commitment to the “quality of life”. By talking about “quality of life” as a complex reference to well-being, this unfailingly brings us to the same definition of health as proposed by the WMO: “Not only the absence of disease or infirmity, but also a state of physical, mental and social well-being”.

In the case of cities, we are facing one of the great challenges presented by the modern-day world: sustainability which, according to the arguments we have set forth, is becoming fundamental in cities. This work is the culmination of a lengthy piece of research which has been published in previous conferences (Sustainable City: 2002, 2004, 2006 and 2008).

There is a field that has been scarcely studied on a global level: the relation between green areas and comfort [2, 3]. This study was started several years ago and the first results have already been published [4]. On this occasion comfort indices were formulated according to the green area in each district in the city, as well as the most appropriate type of vegetation for the city: radiation retention, pollution retention, etc. This research has expanded statistically and geographically in the city of Valencia; confirming a clear path and solution for those responsible for urban planning.

Following active collaboration in the drafting of the Green Plan for the city of Valencia, we were able to undertake what would be the culmination of this study: the zoning and planning of green areas, that is, observing the quantity and quality of the green areas that should be implemented in each district, to study the accessibility criteria that make them correctly useable by the citizens. This study culminated with the formulation of a comfort index for the city of Valencia (Table 1).

In these formulas, the statistical determination continues to be superior to 50% in all of the cases, allowing these formulas to be considered as a reliable tool to obtain a fairly precise idea of the relation between green areas and comfort indices. With these formulas, it would be possible to calculate the amount of green areas required for a district in the city; by only substituting B or D for the percentage of soft or hard ground in the district and giving maximum values to the index, we would obtain the amount of green area per  $\text{m}^2/1,000 \text{ m}^2$  land.



Table 1: Formulation of the WBGT comfort index in terms of the type of ground: “soft zone”, “hard zone” and green zone per surface area, for each district.

<b>FORMULATION OF THE WBGT INDEX</b> (ADAPTED)		
<b>Type of ground</b>	<b>Hard</b>	<b>Soft</b>
<b>Spring</b>	0.1644·m <sup>2</sup> green /1000m <sup>2</sup> surface area	1.1369·m <sup>2</sup> green /1000m <sup>2</sup> surface area
<b>Summer</b>	0.2987·m <sup>2</sup> green /1000m <sup>2</sup> surface area	1.2503·m <sup>2</sup> green /1000m <sup>2</sup> surface area
<b>Autumn</b>	0.9969· green /1000m <sup>2</sup> surface area	0.9586·m <sup>2</sup> green /1000m <sup>2</sup> surface area
<b>Winter</b>	0.9499·m <sup>2</sup> green /1000m <sup>2</sup> surface area	0.9121·m <sup>2</sup> green /1000m <sup>2</sup> surface area

If we add the results from the first part of the study, we will know which species provide the best shade on streets or in parks, those which retain the most pollution, the role they play in city heat islands, etc.

Since ecology has recently become the essential basis for planning regional space, it is vital for modified natural processes inside cities to become the central theme of urban design. The sustainability concept, more recent than ecological science and with more extensive fields of study, is particularly concerned with cities, as these are where the planet's highest population concentrations are found.

As regards the city of Valencia, we would wholeheartedly endorse what is stated in the Leipzig charter on Sustainable European Cities (2007), whose recommendations should be the basis of any reform of urban planning. The most widely used gauge for measuring and valuing sustainability in cities are “sustainability indicators”.

Practically all international institutions and public and private bodies connected with development of cities have drawn up their list of “sustainability indicators” omitted herein through being so well known. In all cases however, one of the indicators considered vital for sustainability in cities is the need for an amount (%) of green space, in respect of the total surface area of the city, and the necessary accessibility to these green zones for a large part of the population. These two questions lie at the base of the research covered in this article and the objectives that will be seen for the Green Plan of Valencia city.

The epigraphs prior to this work analyzed the role of green areas in the city. At present, the role of water (bodies of water, lakes, rivers, fountains, etc.) is being studied and we can predict that it too will play an extremely important role in the improvement of urban environments.

It is clear, therefore, that water and plants are important elements in the improvement of the climate and comfort of a city. But, what is its sphere of influence? How much vegetation or superficial water is needed to achieve a significant effect on the comfort of a city? Where should they be located? [5].

The answer to these questions depends on the region's climate, the type and variations in climate from one place to another, the characteristics of the place, its topography and the characteristics of the city's built area.

One author already suggested that, from a climatic point of view, a combination of small spaces distributed uniformly throughout the city is more effective than the concentration of very large areas in only a few places.

Later studies [6] confirmed that the planning of green areas should be considered from two fundamental perspectives: continuity and accessibility. Both favour an appropriate use by the citizens and conditions in accordance with the function they fulfil in the urban scheme.

Studies conducted in Dallas and Fort Worth showed the advisability of continuous green areas as the best way to achieve filtration and oxygenation of the air as it moves towards the interior of the city, one example of this could be the study of San Louis (Missouri) green belt (Fig. 4). The most recent study in Chicago considered that a master plan with development corridors and open air spaces would have a positive effect on air quality [5].

2 Application to the city of Valencia

The choice of a human settlement has always been a complicated matter, only accessible for experts and those knowing the territory and its long-term dynamics.

We therefore feel it necessary to briefly introduce an historic and present-day vision of the city. As can be seen from Fig. 4, Valencia lies in the east of Spain, by the Mediterranean sea and with an average height of 16 m and a fairly regular relief, on a plain rising gently inland with contours parallel to the coast.

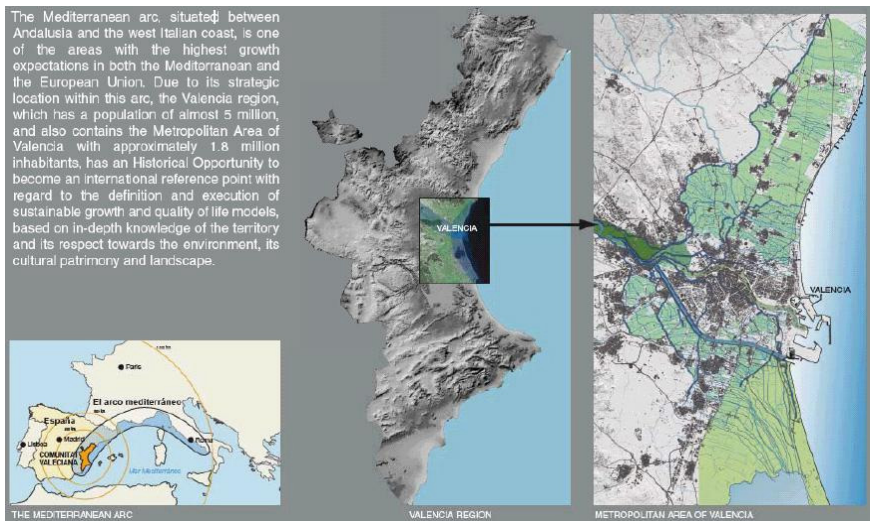


Figure 1: Situation of Valencia metropolitan area.



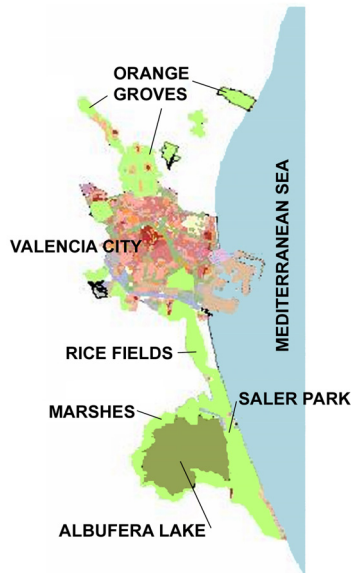


Figure 2: Municipal area of the city of Valencia, with details of its setting.



Figure 3: Huerta de Valencia, classified by the FAO-UNESTO report [6], one of the richest in the world.

Valencia city lies at the lower end of the river Turia flood plain, and was founded on an island between two arms of this river; as it grew the city overflowed the small island and gradually settled on the plain that surrounded this until it became a metropolitan area of 1.8 million inhabitants, counting the number of small municipalities surrounding this.

The river Turia, Valencia's Albufera lake, the Mediterranean sea and the alluvial plain, occupied by the Historical *Huerta* or market garden, all form the exceptional landscape of Valencia Metropolitan area: four scenarios of remarkable cultural and landscape value sharing water culture as their central argument.



Figure 4: Green infrastructure of Valencia metropolitan area: River Turia Corridor, *Huerta*, Albufera lake and Mediterranean Sea.

The *Huerta* is an ancient cultural landscape in which the prominent aspect is the irrigation system, with Roman origins, although it would be in the Arab age when a major hydraulic infrastructure was created with numerous canals, drying out large swampy zones which covered a good deal of the plain around the city. This was how a productive fertile space was gradually created incorporating the knowledge and agronomic and hydraulic techniques from the Near East, managing to become the richest market garden in the world [7], along with the Coazi valley in Colombia, or one of the five most important in Europe, according to the Dobris Report [8].

On this space just defined, the city of Valencia and a further 40 municipalities have grown, originally organically. Regrettably, during the 1960-80s, with their inexorable developmentalism, and no kind of coordination between the urban development of these municipalities, a situation of total lack of understanding between the city and the outskirts was nevertheless reached, as has occurred in practically all the world's cities [9]. At the present time 72% of the heritage elements of great value inventoried in Valencia's *Huerta* are abandoned or in a serious state of degradation.

The urban and industrial development quoted has generated serious dysfunctions in the water system in the *Huerta*. But above all the urban development expectations, the low profitability of farm work and the social devaluation of farmer's work are causing the gradual desertion of the *Huerta*.

The image preferred by Europeans is that of a city surrounded by its landscape but this image is being lost. At this crossroads, the International Seminar on the *Huerta* of Valencia was held in 1994, attended by experts from all over the world with the intention of providing ideas to save this territory. The important contents of the Valencia Seminar were used as a basis for drawing up a Green Plan for the city, with the basic aims of increasing the city's appeal, correcting the contamination and urban discomfort, protecting the market garden, improving the coastline, the water masses, the natural spaces and increasing the areas of active recreation-leisure.

The content of this green planning set out to improve and increase the free and green spaces in the city and in parallel conserve the *Huerta*, since in spite of the diagnosis that we have made of this market garden, there are still quite a

number of its interstices within urban space, though with a high level of degradation.

The spaces in the south have also undergone enormous aggression, although help arrived in time to protect the Albufera lake (protected as a Nature Reserve since 1990, with a Special Protection Plan) and the Saler Park, consisting of 713 hectares of pine trees on the dunes separating the Albufera lake from the Mediterranean, which has been done through the qualification of non-developable land in the latest General Plan for the city.

### 3 Green planning for the Valencia city: analysis

As regards the provision of green spaces, we can see that these are spread over the three types of land found in the city reaching a total amount of 4,279,246 m<sup>2</sup>. Taking into account that the city has 800,666 inhabitants, the provision of green zones is 5.34 m<sup>2</sup> per inhabitant. The World Health Organization has for some years been proposing the need for this provision not to be under 9 m<sup>2</sup> per inhabitant but it has more recently recommended from 10 and 15 m<sup>2</sup> of green zone per inhabitant. This is thus a shortcoming which the city has to overcome. This is the point where the two parts of the paper being presented link up.

Our own research, as presented in the first part of this work shows that the amount of green zone for the whole city, to be considered comfortable (Table 2), is obtained by giving values to maximum and minimum WBGT of the comfort range, which should be from 8.08 to 12.12 m<sup>2</sup>/inhab. (Table 3).

This formula was chosen because this index was already found [1,2004] to be the one that had performed best in the study made on all of these. The reason could be that one of the parameters implicitly involved is ambient temperature (globe), most sensitive to the situation of the microspaces on which the study was based, and for which soft zones (with low reflection) are also most sensitive.

This analysis is made for the whole city because in our case we already know the surface area of Market garden inside the city (Table 2). The surface of Huerta, or market garden, inside the municipal area is 33,820,000 m<sup>2</sup>. 20% needs to be deducted from this figure through infrastructures and its own buildings, leaving 27,056,000 m<sup>2</sup> added to the present green zones, coming to 31,335,246 m<sup>2</sup> in all, which means a provision for the population (800.666) of 39.13 m<sup>2</sup> per inhabitant.

There are proposals for the green zones to be valued in terms of provision m<sup>2</sup> per inhabitant; the English norms [10] set 1 Ha /1.000 inhab. In our case it would work out that green zones should occupy 800 Ha., and as already seen, for the whole municipal area this works out at 3,133.5 Hectares, comfortably exceeding the provision recommended.

Another provision put forward by some bodies is the total percentage of land: in England it considers a standard of 10% of the surface area to be necessary [11].

In our case, starting from the total green zones, the result is 23.27 %, also over that criterion.

Table 2: Surface areas of the municipal area of Valencia (Plan Bureau, Valencia council).

SURFACE AREA OF VALENCIA MUNICIPAL AREA (Hectares)		
URBAN LAND		3,632
DEVELOPABLE LAND		815
NON- DEVELOPABLE LAND	Parque del Saler	713
	Albufera lake and Marshland	2,843
	Rice fields	1,400
	Coastline area	71
	Turia riverbed	226
	Huerta market garden	3,382
	Unirrigated land	112
	Amenities and infrastructures	269
TOTAL		13,465

Table 3: Calculation of the provision of green zones, according to WBGT index formulation.

NEED FOR GREEN ZONES FOR COMFORT IN VALENCIA			
WBGT INDEX <sub>(ADAPTED)</sub>	1.2503·m <sup>2</sup> green / 1000m <sup>2</sup> surface area  (R <sup>2</sup> = 54.23 %)	Comfort ranges	Green zone: m <sup>2</sup> /in hab
SUMMER		Cold: < 58.86	8.08
SOFT ZONE		Comfortable 58.86-88.31	10.1
		Warm > 88.31	12.12

All this would provide the city of Valencia with a proportion of green areas far over what has been established by other bodies or international institutions, thanks to the Green Plan.

This Plan proposes a multiple strategy, consolidating Huerta areas inside the city, creating peripheral parks above all in the north of the city to prevent its growth from destroying the most important and richest part of the Huerta, and consolidating in the south the natural spaces of rice fields, marsh land Albufera lake and Saler park, which though 12 km. from the city centre, contains an extraordinary enclave between the Albufera lake and the Mediterranean.

One aspect linked to the actual provision already mentioned in this manuscript is the radius of influence, which characterises accessibility to green spaces. The criteria for examining this have been used in other planning documents, specifically taken from Canada's Green Plan, perhaps one of the most complete documents drawn up to date [12].

Going by these criteria and applying our radii of action the whole map of the city was analyzed to insert the different types of green area which its people can access (Fig. 5).

The city of Valencia, thanks to its linear River Turia park, has very good accessibility possibilities for a good deal of the population (Fig. 5).



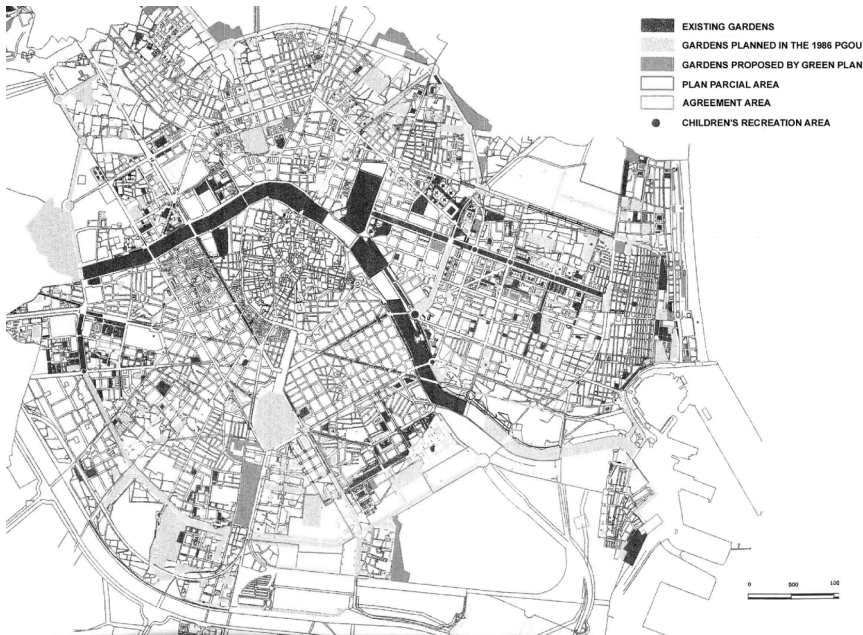


Figure 5: System of play parks proposed, for the city of Valencia, by the technical office of the Green Plan.

#### 4 Special plan for protection of the Huerta de Valencia

For the phase of analyzing the Huerta, however, we considered the methodology of the Special Plan for Protection of the Huerta de Valencia, based on first determining its most valuable landscapes, analysis of its conflicts and tendencies and the establishment of five strategies to guide specific protection action.

These strategies are of interest in this synthesis-prognosis stage: 1) protecting and connecting the landscapes of greatest value; 2) guaranteeing the continuity of farming activity; 3) integrating the infrastructures and urban outskirts in the landscape; 4) protecting and boosting Cultural and Visual Heritage; 5) fostering public leisure use of the Market Garden - Huerta.

The set of landscapes with greatest cultural, productive, landscape, natural and leisure value and the ecological and functional connections between these form the landscape and identity of Valencia's Huerta and should be preserved for future generations, as an interconnected accessible system.

These references are for the whole unit of what we have called the *Huerta de Valencia*, for which reason two spheres must be established.

- The Huerta as a whole, for which this protection concept attempts to place order on the chaos of the 40 municipalities growing on this, creating a continuous system of Green Corridors which ensure the effective separation of municipalities, an improvement in the visual landscape and city people's public enjoyment of the Metropolitan Area.

- The Huerta space inside the municipal area of the city of Valencia, the protection would above all generate a continuous mesh of “green” spaces for this which would structure and guide urban growth of the city.

Going by landscape criteria for the Huerta space inside Valencia municipal area, the study concentrates on the improvement in the perceptive surroundings of the urban zones with visual access to green zones and increased tourist appeal.

Creation of itineraries and landscape routes, with viewpoints, information points, interpretation centers and leisure areas, making use of the existing farming structure, particularly using the historical network of paths and irrigation channels (paths, cattle tracks, canals, dams, etc.).

This synthesis phase goes deeper into the other strategies, above all in the territorial, landscape and socio-economic analysis of the Huerta, stressing that the protection of its heritage and cultural assets involves maintaining farming work.



Figure 6: Peri-urban spaces – the connection between the Huerta and the city.

To this end, management formulas are being developed based on the farmer, the increase in the competitiveness of farm work, the development of open and mixed financing formulas, the offer of new farming, cultural and tourist services and lastly the creation of a body managing these strategies. Another of the tactics used was the landscape integration of transport infrastructures (Fig. 6).

The urban outskirts were studied, specifically the transition zones between urban space and the Huerta, through requiring an intervention strategy enabling consolidation of the limits of the Huerta and inviting the citizen to visit and enjoy this. This was one of the objectives of the Green Plan, one should remember.

This penetrability and mutual accessibility between the city and Huerta is marked by the location and painstaking design of the Rest Areas, located on the extensive path network, which facilitate its public and recreational use. The idea behind this mutual rapprochement is that citizens should get to know traditional ways of life, farming culture and the architectural heritage of the Huerta, transformed into a wide range of didactic, recreational and service offers. Since the International Seminar on the Huerta (1993) was held there has been a very clear conviction of “getting to know the Huerta being the first step towards protecting this”. Protecting the Huerta necessarily involves city people’s persuasion of the environmental, social and economic benefits stemming from conserving this.

## 5 Diagnosis

The diagnosis is a convincing document, with a short description acting as a sound preliminary to the planning proposals. In parallel with the diagnosis, either before, after or simultaneously, the solutions helping to understand the processes and sustaining the conclusions of large groups and knowledge forums are of great interest.

\* There is great interest in improving the environmental quality of the city and protecting the Huerta; the landscape, culture and history of both are highly valued.

\* The Huerta is open space, with water, pathway and plot structures, with its own agrarian activity and with crops that can be varied. This space can and should enrich the environmental conditions of the city of Valencia.

\* This whole process involves finding a protection concept for the most fragile space and this requires a management system enabling the continuity of farming activity.

\* The clearest way to ensure farm work involves improving the profitability of farm produce, through agrarian and market mechanisms, though it will always require the economy of complementary activities in order to be comparable with other activities, in which the city must take a major role.

\* The protection and maintenance of work in the Huerta must be paid by the beneficiaries, those who value this and want its protection: the city and its inhabitants.

In view of and as a conclusion to this diagnosis, only two possible alternatives come to mind (Figs. 7 and 8).



Figure 7: The city of Valencia: without protection of the Huerta.



Figure 8: The city of Valencia: with protection of the Huerta.

## 6 Conclusions

This work presents the second part of a more extensive piece of research, performed in the city of Valencia (Spain), on the role of green zones in city planning. It reaches a precise formulation of three of the comfort indices used in the research for Valencia city.

This second part starts by analyzing the updated international bibliography on city environment and sustainability, the present concept represented by green zones and comfort in today's cities, the relationship of both concepts, and ends up by explaining the latest conclusions of research in these fields.

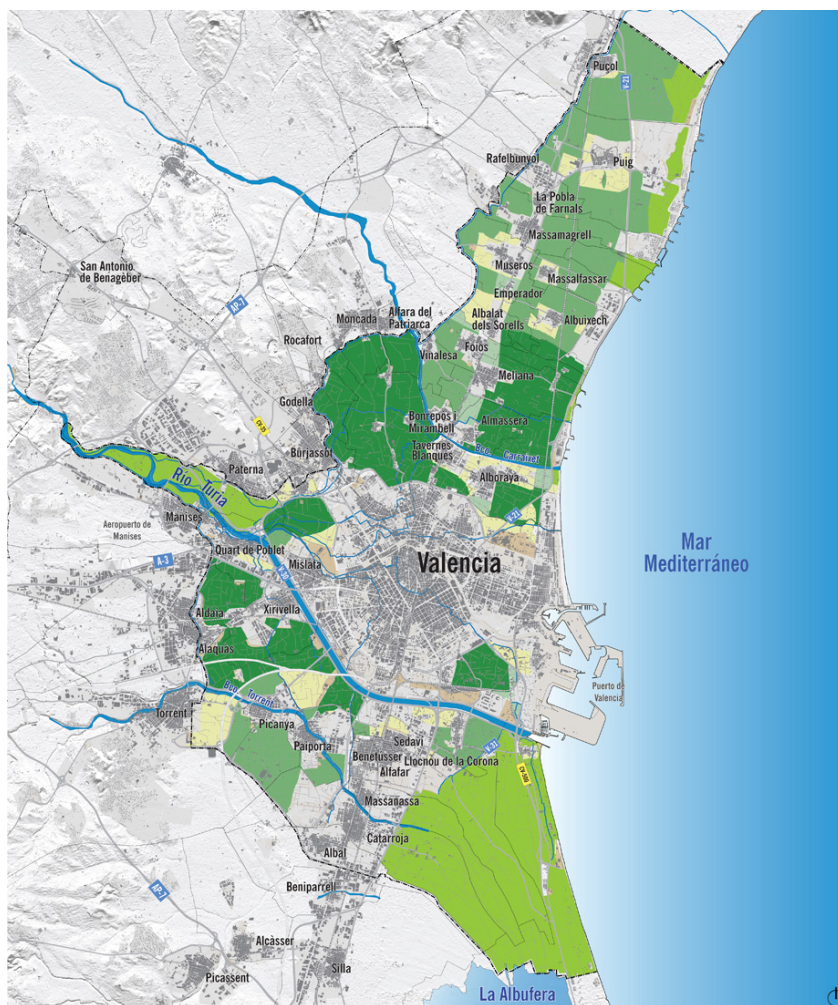


Figure 9: The proposal for zone-planning for protection of the Huerta de Valencia and integration with the city.

An attempt has been made to make this study a piece of applied research; analyzing the participation of previous research and reaching the conclusion that an improvement in the amount and arrangement of green areas in the city is very important, but not sufficient for a city sustainability approach.

The recent Plan for Protection of the Huerta is analyzed, since without departing from the Green Plan philosophy, this represents an updating of the

proposals of European Territorial Strategy and the European Landscape Convention.

The final result of the application of this research is not altered by the simultaneous implementation of these two studies, since the second of these, though with methods more appropriate for European proposals, reaches the very same conclusions – the need for protection of the Huerta.

All of this leads us to a proposal for planning in the sphere of sustainability, with a management plan very close to the actual situation (Fig. 9).

## References

- [1] F. Gómez et al., (2002) The Green Zones, main factor of urban regeneration and of city sustainability, Second International Conference of the Sustainability, Segovia (Spain), 3-5, July.  
F. Gómez et al., (2004) Climate indicators for cities, 3rd International Conference of the Sustainability, Siena (Italy), 16-18 June.  
F. Gómez et al., (2006) Sustainability in cities: the green areas and climatic comfort as fundamental parameters, 4th Conference of the Sustainability, Tallin (Estonia), 17-19 July.  
F. Gómez et al., (2008) Vegetation influences on the human thermal comfort in outdoor spaces: criteria for urban planning, Skiathos (Greece), 17-19. Sept.
- [2] Salvador, P. and Smith, D.R. (1987) Vegetation and urban climate in Valencia, Spain. A Pilop Project, Mab-Unesco.
- [3] Kwi-Gom-Kim. (1989) Climate, urbanization and green spaces in urban areas, the case of Seoul, Mab-Unesco, University of Seoul.
- [4] Gómez, F., Jabaloyes, J. and Salvador, P. (1997) Climatic comfort in the spaces opened of a Mediterranean city, VIII Congress Ibérico of Solar Energy: *Energía Solar e qualidade de vida*, Porto, 26-28 Maio.
- [5] Nikolopoulou, M. and Lykoudis, S.: (2006). Thermal comfort in outdoor urban spaces: analysis across different European countries, *Buildings and Environment*, 41, pp. 1455-1470.
- [6] FAO-UNESCO. (1974), *Soil Map of the World, Revised Legend*. World Soil Resources Report 60. FAO, Rome, Italy.
- [7] Dobbris Assessment, (1995), *Europe's Environment*, European Environment Agency, Ed. D. Stanner & P. Bourdeau, Copenhagen.
- [8] Hills, R.D., (1986), *Changes in land use in urban fringe*, UNESCO, Vol. XXII, nº 1 and 2.
- [9] Plan Vert Regional D'ile de France, Mars 1994.
- [10] Gouvernement du Canada. (1990) *Le Plan Vert du Canada*, Hewson, Bridge and Smith Ltd. Quebec.
- [11] Plan Vert Regional D'ile de France, Mars 1994.
- [12] Gouvernement du Canada. (1990) *Le Plan Vert du Canada*, Hewson, Bridge and Smith Ltd. Quebec.

