EL MODELO BARCELONA DE ESPACIO PÚBLICO Y DISEÑO URBANO: Public Space and Flood Management | *Dipòsits d'aigües pluvials*

Trabajo final para la obtención del grado de Master en Diseño Urbano: Arte, Ciudad, Sociedad

Autor: Maria Matos Silva | Tutor: Prof. João Pedro Costa | Enero 2011

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Facultat de Belles Arts

UNIVERSITAT DE BARCELONA

ABSTRACT

This paper addresses the different relations between “public space” and “flood management infrastructures” existing in the city of Barcelona. It aims to promote the importance and necessity of an integrated approach that links infrastructures and public space design through the knowhow of concrete examples. Firstly a parallel research will take place, on the history and design process of “Modelo Barcelona” and this city’s adaptation to its particular climate trends. Secondly, the relations between Barcelona’s “dipòsits d'aigües pluvials” and their surrounding public space will be analyzed, seeking to know whether these two urban elements work together or separately and if they can be considered examples susceptible of exportation to other similar cities like, for example, Lisbon.

The development of this paper aspires to enhance higher confidence on the fact that all planning stages should be interconnected in a transversal and integrated approach that allows the advantaged use of all possible opportunities in the design process. Concerning the particular case studied, adding public space design to rain-water drainage infrastructures is considered to be not only feasible but a win-win situation.

Key words: Barcelona, Floods, Public Space, Infrastructure.

RESUMO

O presente trabalho aborda as diferentes relações entre "espaço público" e "infra-estruturas de gestão de inundações" existentes na cidade de Barcelona. Tem por objectivo promover a importância e a necessidade de uma abordagem integrada que relaciona as infra-estruturas e o design de espaço público através do estudo de exemplos concretos. Em primeiro lugar será realizada uma investigação paralela que abordará tanto o processo histórico de concepção do "Modelo Barcelona" como a adaptação desta cidade face às suas particulares tendências climáticas. Em segundo lugar, as relações entre os “dipòsits d'aigües pluvials” de Barcelona e seu espaço público envolvente serão analisados, procurando saber se estes dois elementos urbanos trabalham em conjunto ou separadamente, e se este conjunto pode, por sua vez, ser considerado um exemplo passível de exportação para outras cidades semelhantes, como, por exemplo, para Lisboa.

O trabalho desenvolvido pretende aumentar a certeza e confiança no facto de que todas as fases de planeamento devem ser interligadas numa relação transversal e integrada, permitindo a inclusão todas as possíveis oportunidades no processo de desenho. No que diz respeito ao específico caso de estudo analisado, será demonstrado que a fusão entre o “desenho de espaço público” e “infra-estrutura para a drenagem de águas pluviais” não só é possível como pode facilmente resultar numa relação de simbiose.

Palavras-chave: Barcelona, Cheias, Espaço Público, Infra-estrutura.

INDEX

GLOSSARY OF ABBREVIATIONS

4AR	4th Assessment Report of the IPCC
ACA	Agència Catalana de l'Aigua
CLABSA	Clavegueram de Barcelona, S.A.
CML	Câmara Municipal de Lisboa
CSO	Combined sewer overflows
CSS	Combined sewer system
DGPC	Direcció General de Protecció Civil
INUNCAT	Plan Especial de Emergencias por Inundaciones de Cataluña
IPCC	Intergovernmental Panel on Climate Change
OECC	Oficina Española de Cambio Climático
PAM	Planes de Actuación Municipal
PECB	Pla Especial de Clavegueram de Barcelona
PECLAB	Plan Especial de Alcantarillado de Barcelona
PEFCAT	Planificación de Espacios Fluviales de Catalunya
PERI	Planos especiales de reforma interior
PGDL	Plano Geral de Drenagem de Lisboa
PGM	Plan General Metropolitano
PU	Plano de Urbanização
TGB	Plan Congost del Besòs

1. INTRODUCTION

Water is a vital resource, but beyond the acceptable thresholds it becomes a risk. When the upper threshold is surpassed, the flood risk is considerable, but when values are below the lowest threshold, there is a drought risk. These thresholds are non-stationary over time. The lifestyle of developed countries is leading to a narrower range of tolerance, and this fact, combined with an increase of the population and other factors, points towards higher vulnerability. In parallel, the last Intergovernmental Panel on Climate Change (IPCC, 2007) shows an increase of the extreme hazard as a consequence of climate change. If both hazards and vulnerability occur simultaneously, then we will be speaking about a severe expansion in some natural risks (Llasat et al., 2008). Nowadays it seems that this increase in some natural hazards is already taking place. However, in some regions it is still too soon to determine whether this is a trend caused by climate change, whether it lies within the boundaries of natural climatic variability, or whether it is only associated with the amplified vulnerability.

For thousands of years, societies have adapted their cultures and economies to their climatic and hydrologic geography. Many human activities are intricately linked to the natural flow regime and character of streams and rivers. Since the Industrial Revolution, and especially in the last 50 years, mankind's accelerating demands for energy, water supply and developable land have transformed the nature and character of water resources in many parts of the globe. 'Water development', through dams, diversions and levees, has altered the natural hydrologic regime in response to economic demands (Williams, 1989). But still the world is no static natural system and once realizing that today the scientific consensus on climate change is already satisfactorily robust, and that this is a matter where it is particularly pertinent to evoke the precautionary principle, any uncertainty that might still exist must not be a reason to postpone the awareness of the society's necessity to adapt to climate variability.

In Europe, floods have been recognized as a major natural risk because of their frequency and also because of the registered precipitation intensity levels. In particular, Mediterranean countries are usually affected by natural hazards occurring every year, leading to the loss of human lives as well as to considerable economic harm. Next to droughts, floods are the most important natural hazard in this region (Botija et al., 2007). Within the boundaries of the Iberian Peninsula, Catalunya is one of the most affected areas. In fact, a total of 217 flood events were registered in this region between 1901 and 2000, most of them near the coast (Llasat, Lopez, Barnolas and Llasat-Botija, 2008). Catalunya, and especially its coast, is particularly vulnerable to flash-floods. This vulnerability reveals itself from a physical point of view (residential areas built on floodable land) and from a social point of view (increased population density, growing number of foreigners who are not familiar with the risks in the area and do not know how to react, lack of information campaigns related to these risks) (Llasat, Lopez, Barnolas and Llasat-Botija, 2008).

In order to fight against the frequency of floods caused by extreme precipitation events, Barcelona has prepared itself, in recent years, through a network of large capacity tanks that capture rainwater. The so called "dipòsits d'aigües pluvials" were built with the primary purpose of water flow control, increasing regulatory capacity to the drainage system, preventing possible floods during the rainy season and avoiding water discharges from untreated sewage. It is politically advertised that because of this infrastructure "Barcelona is prepared for all rain storms" (Jordi Hereu in (Doncel, 2010).

As urgent as it is to adapt to extreme weather, and as much as climate change is, for now and in some countries, far from any political recognition, this paper doesn't aim to generate alarmism, but rather to provide a series of information, associated with concrete examples, that show the opportunities that go alongside with climatic variability. Especially for the city of Barcelona, the association between "public space" and "water management infrastructure" is of major interest. The success of this relationship, particularly concerning the "dipòsits d'aigües pluvials" and the public space directly associated with them, will be explored both in theory, as a subject that should be a part of urban planning and design, and in practice, by giving existing examples of good dialogue between those two urban elements.

The message aspires to be clear: that the gains and advantages of a transversal and integrated approach between infrastructure and public space design may be greater than the impacts of a changing climate.

This report corresponds to the evaluation of the subject "El model Barcelona d'Espai Públic i Disseny Urbà" and, according to its title, it aims to deepen the understanding about public spaces in "Modelo Barcelona" and its referenced Urban Design. As this is the final report of the Master "Disseny urbà: art, ciutat, societat" it will also aspire to include, directly or indirectly, the learned knowledge on the subjects of its curricula.

Considering that Barcelona is not only known by the inherent quality of its public space, but also by its natural characteristics, which promote frequent flash flood hazards, it was realized that it could be interesting to further investigate the linkage between "public space" and "flood management" in Barcelona city.

On the other hand, and following the line of investigation of the project in progress "Urbanized Estuaries and Deltas"[1], it is commonly accepted by scientists that, among other factors, the extreme weather events like droughts and rain storms will increase in frequency and intensity. Especially in densely populated cities like Barcelona, if this forecast is not taken into consideration, the manifestation of nature can be violent, i.e. flooding, dust storms, landslides, etc, can get more and more dangerous. These facts can be added to the pertinence of the chosen subject, since they mean an opportunity to evaluate possible adaptation measures regarding climate change that not only focus on the extreme events, predicted for all over the world, but also relate these events to public space design and urban planning.

This paper addresses the different relations that exist in the city of Barcelona between the "public space", designed by architects, urban planners, landscape architects, sculptors, etc, and the "flood management infrastructures" designed by engineers. This theme comes from a wider one: the relation between urbanism/natural systems/infrastructure, which nowadays is a very relevant subject that is actually being studied by the professors Han Meyer and João Pedro Costa, for instance.

Attached to this issue is the initial hypothesis, which considers that Barcelona's "dipòsits d'aigües pluvials" (rainwater retention tanks) could be a first attempt of good interrelation between those two urban intervenients that usually work separately[2]. Conversely, these infrastructures and their design, both under and above ground, and even the design process they assumed, can also be a very good example for other countries on how to adapt to extreme rain events.

The general goals proposed for this report are the subsequent:

- Systematization and analysis of the history and design process of Barcelona's "public space";
- Introduction of "adaptation measures to extreme events" in the subjects of urban planning;
- Introduction of needed urban infrastructures in the scope of public space design;
- Promotion of the importance and necessity of an integrated approach between infrastructures and public space design;
- Endorsement of the need to identify concrete design solutions that, together with infrastructures, aim to adapt urban space, public or underground, to the impacts of climate change.

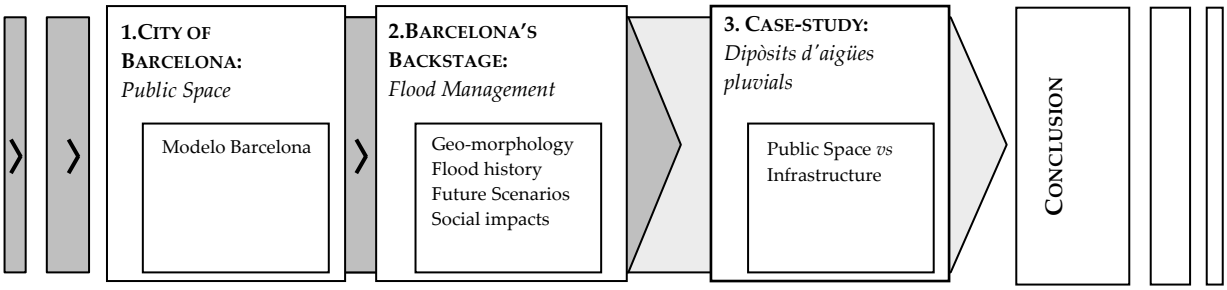
And the specific proposed goals are the following:

- Deep revision of the intrinsic characteristics of public space in "Modelo Barcelona";
- Understanding Barcelona's rainwater management characteristics through the city's morphological uniqueness, hazard history and adaptation history;
- Study of Barcelona's "dipòsits d'aigües pluvials", including the identification and systematization of the relations between the deposits and the spaces (public or not) on their surface.

[1] Project reference of FCT (Fundação para a Ciência e Tecnologia): PTDC/AUR-URB/100309/2008; Full title: "Urbanized Estuaries and Deltas. In search for a comprehensive planning and governance. The Lisbon case"; Project Coordinator: Prof. João Pedro Costa.

[2] A special thanks to Prof. Nuria Ricart from whom I first heard about such deposits and to Prof. Joaquim Sabaté who encouraged me by supporting the pertinence of this research.

To achieve the proposed goals, the following methodology was designed:



1. City of Barcelona, Public Space:

In order to fully understand the concept of "public space" in the context of "Modelo Barcelona" a primer historical evolution of the city, especially regarding its public spaces, is fundamental. From medieval ages until "franquismo"[3], from "franquismo" until "modelo Barcelona" and from "modelo Barcelona" to nowadays, the city's urban planning processes and ideals will be elucidated.

2. Barcelona's Backstage, Flood Management:

Simultaneously, in order to better understand how Barcelona reacts to its usual extreme rain events, which often lead to floods, it is essential to study the city's morphological characteristics as well as the real frequency and intensity of the so called "flash floods". Also, both the identification of the primer relations between the responsible public entities as well as the media and social impacts of floods are considered significant topics to better understand the processes of Barcelona's rain water management.

Nowadays, one must not forget to include the known impacts of climate change every time subjects related to climate variability are studied. For this reason it will also be included a small analysis on the Spanish and Catalonian reports on possible impacts as well as the known mitigation and adaptation national strategies.

3. Case-study, *Dipòsits d'aigües pluvials*:

After the previous research, that can correspond to the state of the art of both Barcelona's public space and flood management (legislative, policy, historical, cultural and social wise), it is easier to learn about and comprehend the chosen case-sudy: the "dipòsits d'aigües pluvials". The research on this case-study will be divided in two parts, a first part that will focus on the characteristics of Barcelona's particular sewage system and a second part that will focus on the particular identified duplicities between 'infrastructure' and 'public space'.

In the final considerations, such system and of such relation, between necessary infrastructure and public space design, will also be valued by the questioning of its applicability in a Mediterranean city with climatic similarities, leaving an open question to future research: can the studied system, of necessary public structures and necessary public space, be useful to minimize the impacts of flash floods in other cities, for example at Alcântara Valley in Lisbon?

This paper is not an extensive and meticulous investigation but an introductory work, aspiring to open possibilities of further research.

Spanish and Portuguese citations were maintained in their original language, once the author's translation was, in the case of this report, considered unnecessary.

[3] Referring to a period of Spanish history, between 1939 and 1975, when Spain was under the authoritarian dictatorship of Francisco Franco.

2. PUBLIC SPACE IN BARCELONA

The following chapters briefly review the history of public space in the city of Barcelona, including its subsequent intervention strategies. There will be given a special focus on "Modelo Barcelona" due to its internationally known importance as a potentially good example on how to plan and build a city.

CITY'S EVOLUTION BEFORE 'FRANQUISMO'

Barcelona is a city with more than 2000 years of history. It has always been a provincial town since it has never been the capital of a monarchy or any important state. This characteristic deeply marks the design of the first public spaces. In the medieval times, Barcelona was a city where apparently there was no court and so there was no "need" for public spaces. The only existing public place in that age was the famous Rambla, pending to the sea (fig.1). The city was confined within its walls in a dense mesh and there was no practice of public space as a leisure social place, the existing ones were for commerce and its design was spontaneous.

Fig. 1 - The Rambla, the city's liveliest public space since the 15th century. Source: (Busquets 2004).

Although there was no manifestation of intentionally designed public spaces, people needed the contact with the outside even if it was just with the family. According to M. Casanovas, between XVI and XVII centuries a survey was made to analyze the city's empty spaces, concluding that the majority were inner courtyards of private homes, meaning domestic public spaces (Casanovas, 2004). This aspect of open interior spaces automatically makes us think about the similarities with the medieval Arab towns.

Fig. 2 - View of the walled town at the start of the 19th century. Source: (Alemany, 1998).

In the first half of the XIX century, at the peack of the industrial revolution, the cities remained with a medieval urbanism but the mesh surrounded by wall was even more compressed by the installation of new industries and by the accelerated demograhic expansion.

The city of Barcelona didn't escape this situation. The fact that all the land outside the wall was military, including the fortification itself, prevented the installation of new industries outside and around the walls. Indeed, the land outside the walls was for exclusive agricultural use, it was totally forbidden to build in that space (fig.2). This way, the installation of industries, and also the associated demographic expansion, was "forced" to be located in separate towns that today are the city's neighborhoods of Sants Sarria, Sant Andreu and Sant Martí (fig.3).

icart i Cia. factory producing ıbric in Sant Martí in the Plain in 1852. Source: (Busquets

The need for people to communicate was very strong, and so a series of new routes that linked the industrial zones to the city "inside walls" was born. 'Passeig de Gracia' is included among these routes, which in that time was not only a mean of communication but also a meeting place that even included its own side gardens and recreational areas[4] (fig.4).

Fig. 4 – Passeig de Gràcia at 1821. The first outdoor space beyond the twon walls, in the plain. Source: http://www.passeigdegracia.cat/

[4] *in* ARTEHISTORIA. El Paseo de Gracia (Barcelona). vol. 2010, no. April. Available from Internet:<http://www.artehistoria.jcyl.es/histesp/contextos/6170.htm>.

The industrial revolution brought new uses and functions to the city. The urban design and public spaces gained new concepts as architecture began to change into a densification of vertical and dense growth, destroying most of the medieval architectural elements. The quality of urban life began deteriorating. Questions about the viability of the industrialization process started alongside with it the "sanitarian movement", which was specially associated with planning as a way of trying to reconcile "progress" and "quality of life". Following the "sanitarian process" and in order to prevent cholera, cemeteries were created. Subsequently, a Spanish law arises, expropriating ecclesiastical land and assigning it to the Spanish liberal bourgeoisie (Busquets, 2004).

It is interesting to notice that this law was applied by the people, who were tired of the church. This change in people's attitude towards the clergy resulted in major manifestation events that burned almost all the churches. As a consequence, the burning of churches and convents ended up liberating a big amount of space inside the city's fortress (fig.5). For the city of Barcelona this was probably the most significant time of architectural and human destruction. Riots became commonplace and anti-church demonstrations occurred in 1835, 1909 and in 1920s[5].

Fig. 5 - The burning of convents in 1835 ultimately freed up a lot of space in the walled enceinte. Source: Busquets 2004).

At this time, Barcelona had the good fortune to have as city mayor Francesco de Paula Ruis i Taulet, whose forward thinking ideas created the "Barcelona Great Exposition" in 1888 having removed, in 1878, all trace of the hated fortress "Citadels" constructed under Felipe V. Meanwhile, the population of the city had expanded from a mere 110,000, in the beginning of the 1800s, to over a million by 1930, due to the demand for labor in its industrial expansion (AA.VV., 1991).

Considering the containment of the former city limits, the increased population density and the communication problems with the outside, an extension plan for Barcelona was considered necessary. In 1859 Ildefonso Cerdà designed his idea of how that extension should be, proposing the "Ensanche" ("ensanche" is the Spanish word for "expansion", in Catalan is "eixample") (fig.6). He basically proposed a re-foundation of Barcelona, both by the nature of the proposal and its scale (Tarragó, 1996).

Although the "Ensanche" is now considered Cerdà's major work, initially his plan was very criticized by the municipal authorities and by the majority of barcelona's bourgeoisie. It was in fact a plan that had to be imposed by Madrid's administration with the royal law of the 31st of May of 1860 (Ridruejo, 1972).

The project embraced the entire Barcelona Plain, incorporating the bordering municipalities where Barcelona did not have any jurisdiction, but in Cerdà's opinion it was necessary to organize them as part of the assembly. One should remember what was mentioned before; the space outside the walls was empty due to military restrictions in the sector. Barcelona was a city under military control. Nothing could be built within a 1.25Km radius of its walls: the shooting distance of the cannons (Busquets, 2004).

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[5] *in* WWW.SPAIN-BARCELONA.COM. Barcelona - History. 2002, no. 10-11-2010. Available from Internet:<http://www.spain-barcelona.com/barcelona/history.htm>.

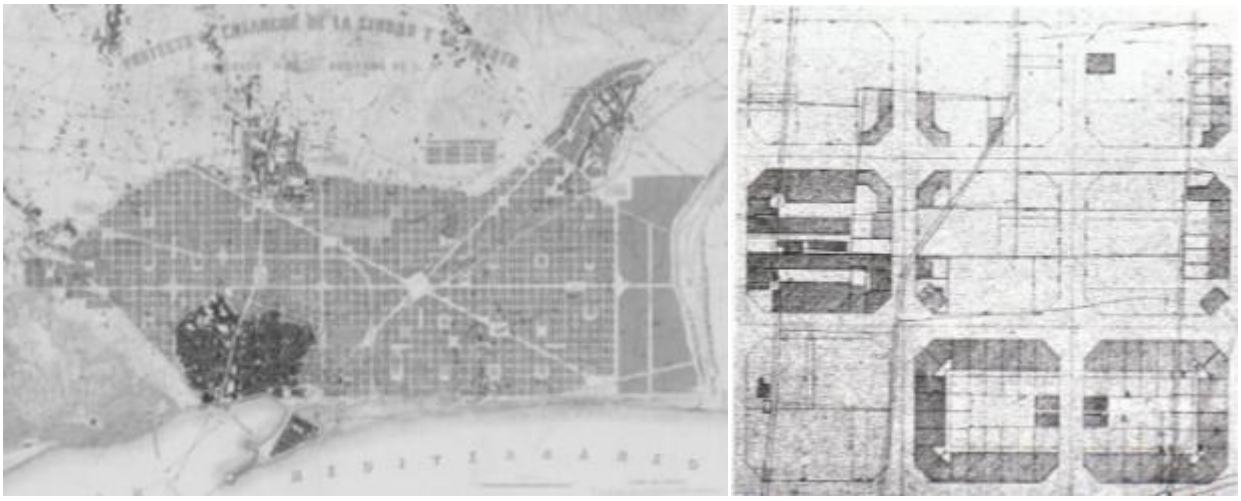


Fig. 6 - *Plano del Ensanche de Barcelona de 1863* of I. Cerdà and a detailed fragment of 1865. Source: (Corominas and Busquets, 2009).

Fig. 7 - Urbanization work in the *Gran Via*. Source: (Tarragó, 1996).

The main objective of his plan was to expand the city beyond the ancient walls, increasing its total area as well as providing an alternative to more orderly streets and blocks, compared to the "dispersed" urban configuration of Barcelona´s historic center. Cerdà's ideas for public space were rather unique, projecting for 880 hectares of land, 550 blocks in-between streets of 20 to 50m wide (fig.7).

Ildefonso Cerdà aimed to improve the living conditions of the whole society (by following his sanitarian ideology), as well as the flow of transport and mobility. The base of the plan is a system of roads and blocks which could be indefinitely extended as the city was growing. Cerdà creates a hierarchy where minor streets flow into major streets that, in turn, flow into large avenues. To explain this hierarchy concept, Cerdà uses the analogy of small rivers flowing into rivers increasingly larger and wider.

The plan is known today mainly for its graphical representation with its reticulated characteristic (fig.6 - detail). This, however, is not just a simple grid that stretches from the ancient city limits. The plan presents a complete system that distributes parks, industry, commerce and residences in a balanced manner. The main avenues form structures that coordinate the blocks' expansion. The blocks, now filled in on all sides, were conceived as open blocks, which allowed a greater flow of people and air in the city, as well as the implementation of green areas (fig 6 - detail).

Basically, and again because he was strongly influenced by the sanitarian movement, he focused on key needs: primarily, the need for sunlight, natural lighting and ventilation in homes; the need of nature in people's surroundings; the need for an effective waste disposal including good sewerage; and the need for ideal movement of people, goods, energy, and information. Cerdà considered that the radial plans like Haussmann's for Paris or the concentric ones like the *Ringstrasse* in Vienna, fomented the cities'

congestion. He aimed, therefore, for the maximum homogeneity of the urban network and the good connection with the outside of the city, both at sea, rail and road.

Adding to the visible qualities of the project, one should consider its invisible aspects, as the planning for rain water drainage, which included an integral design that encompassed both the initial construction and its maintenance. In fact, for Cerdà, the key point of the sewage network was the correct treatment of the pluvial waters (Cerdà, 1867).

According to Busquets, great flooding in the plain conditioned Cerdà's drainage proposals, and it was García i Faria who later came up with an integrated solution (fig.8). Nevertheless, it is important to notice that Cerdà had a detailed knowledge of the territory, due to the fact that in 1855 he developed, with his team, the topographical map to enable him to carry out the project for the extension of Barcelona. The execution was very precise, "Lo que el estudio topográfico de todas las localidades nos enseña, es que al pasar la edificación del estado rural al de urbanización, es decir, al agregarse casas á casas, estableciendo entre sí una combinación cualquiera, que siempre hubo de ser asaz imperfecta, los desagües de las primeras vías urbanas hubieron de ser los mismos que tenía ya el terreno en su estado rústico ó rural, ó séan los regates y arroyos que forman naturalmente las aguas pluviales en su caída y corriente." (Cerdà, 1867), (fig.9).
The rigor in Cerdà's analysis is similar to a contemporary sewage plan. The "Ensanche" itself, with its NE-WS orientation, was conceived for a better water drainage. Its design allowed vertical axes with maximum gradient perpendicular to Barcelona's coast (fig.10). And it is interesting to notice that he also advises for the need to clean the streets specially before the rain season (Tarragó, 1996).

Fig. 8 - Great flooding in Barcelona's Plain influenced Cerdàs drainage proposals. Source: (Busquets, 2004)

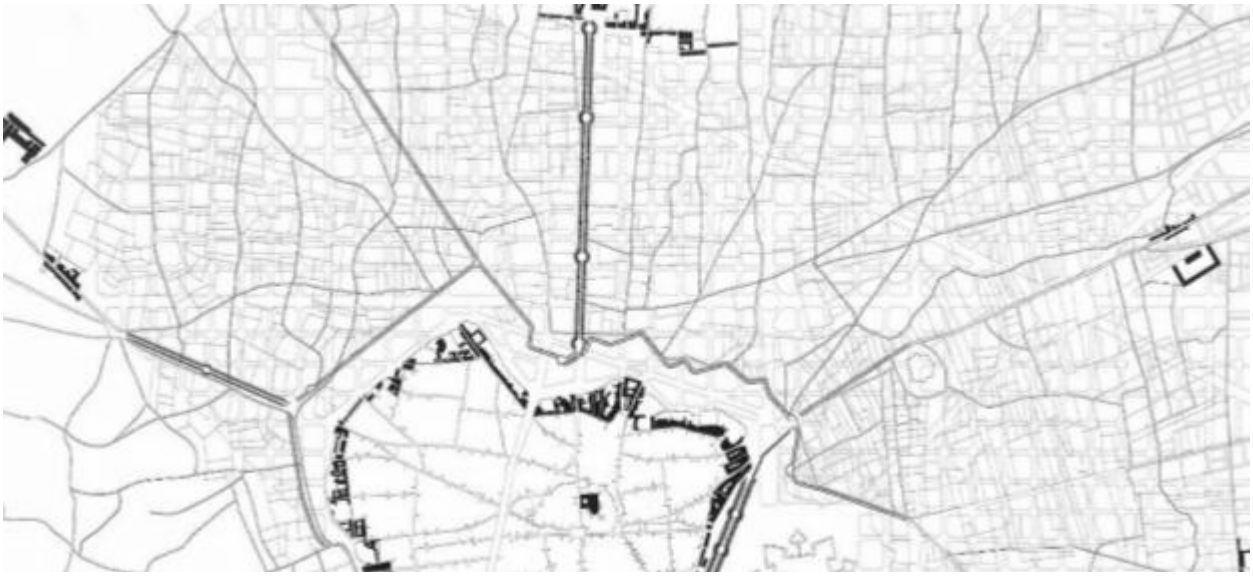


Fig. 9 - Overlay of the *Ensanche* Plan of Barcelona with the former agricultural reality. Source: (Corominas and Busquets, 2009)

But, before considering the Ensanche's own sewage network, Cerdà defended the necessity to build a collector that would defend the new expansion from rain storm floods: "En vista pues de las omisiones sufridas en los ensanches anteriores, respecto á la extracción ó desvió de las aguas torrenciales que viene de la montaña, y conociendo los funestos efectos que han ocasionado y los que ahora pudieran motivar; nadie pondrá en duda la necesidad de hacer este desvio por medio de una rambla de circunvalación, conforme indicamos en el plano general" (Cerdà *in* (Tarragó, 1996)) (fig.11).

"El Ramblar Colector", the "Ramblar" collector, became one of the main features of the "Ensanche" Project of 1859. To defend this particular project, Cerdà expressed his opinion based essentially on historical facts: "La historia patentiza como debe este tener lugar bastanto invocar los precedents para dar con la solución" (Cerdà *in* (Tarragó, 1996)). For Cerdà it was mandatory to separate the water courses through concentric collectors.

It took many years until the talent of the project was recognized and approved by the City of Barcelona. Nowadays Barcelona's Ensanche is better suited to road traffic and pedestrian movement than many of other neighborhoods built after the arrival of cars. As important as the drawings are the theories developed by Cerdà that are presented in the memoires of the plan, like the following ones:
- The city works in a double concept: movement and rest;
- The streets must provide a network infrastructure, enable transport and provide the best possible lighting and ventilation of houses;
- The transportation system is fundamental to an appropriate city functioning;
- The plan must allow unlimited extension of the city;
- There must be unity and connection between the old and new city.

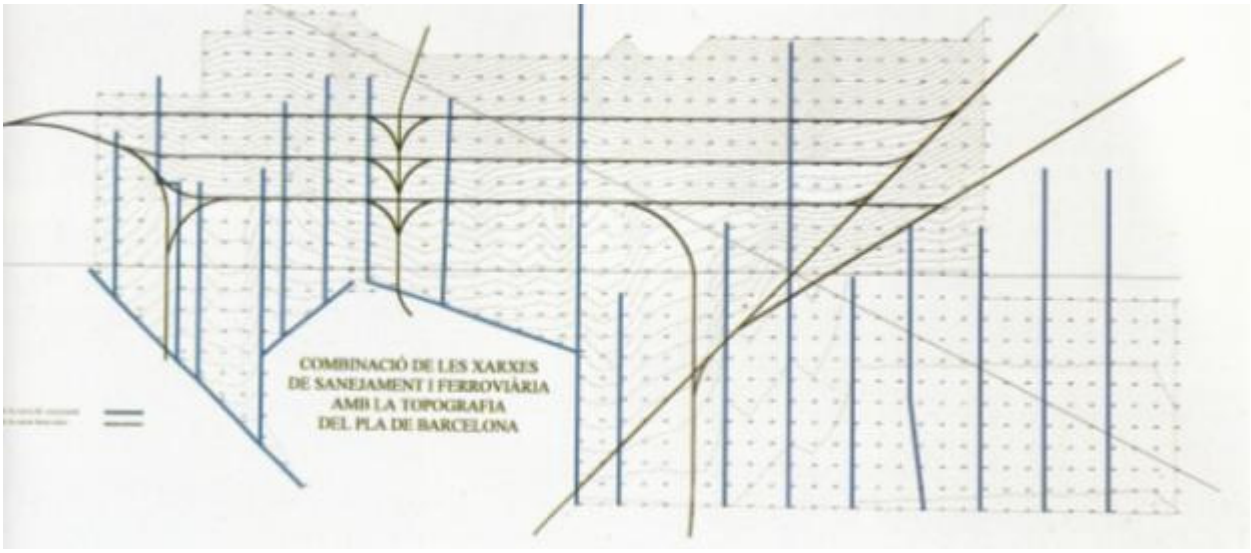


Fig. 10 - Deduction of the sewage network from the plan's topography. Source: (Tarragó, 1996).

Fig. 11 - *Ramblar Colector* proposed for the Ensanche project of 1855 and also in 1859. Source: Adapted from (Tarragó, 1996).

The years between 1936 and 1939 were very difficult for Barcelona once, in the Spanish civil war, the republicans were defeated. Because this was a dictatorship period, Franco had the power to delegate the "alcaldes" (mayors), which in 1939 proved to be a strong threat to the balanced growth of Barcelona. The mayor of Franco's choice, named Josep M. Porcioles, eventually "sold" Barcelona to investors, revealing his bad management of urban planning – eventually, they started to built outside the urban-territorial city, with no limitations and/or a guide-line structure. "la forma de gestió i la pressió especulativa va conduir a admetre una edificació escandalosament abusiva que ha produït dos resultats catastròfics" (Bohigas, 1986). Another "curiosity" of this mayor's work was that he didn't invest a penny in public space. By this time, Barcelona continued to be a city without public spaces, or the ones that existed had no quality.

POST-'FRANQUISMO' PERIOD

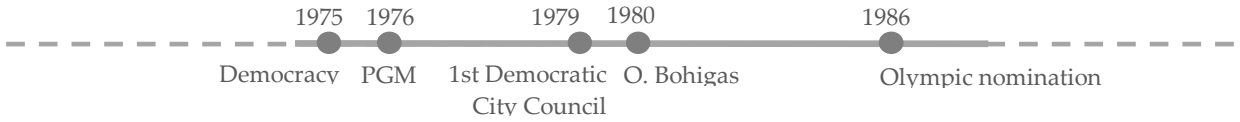
During the democracy period, since 1975, public space also experienced major shifts.

The urban planning project for Barcelona, during the democratic period, took form from a series of ideas and incomplete projects, with the participation of various actors and with different contextual references and specific goals throughout the period. It began a new stage of strategic development.

The year 1976, in which the General Metropolitan Plan – PGM – was approved, should be considered as the starting point and reference of this new era (fig.13).

This plan was maintained throughout the whole process, although its importance would change as a result of actions becoming, in time, more distant from it. 1979 was the year when the first democratic City Council "entered office". In 1980 there was an important change in the City Council urban planning team, with the substitution of Joan Anton Solans by Oriol Bohigas as the Services and Urban Planning secretary and also the incorporation of Joseph A. Acebillo into the team.

The Olympic nomination, which was received in 1986, is another key date in the sequence, as it introduces significant changes into the development of the city.



Based on previous studies conducted during the dictatorship, Oriol Bohigas strengthened an empirical base of knowledge that led him to develop a strategy for planning and intervention in the city - now known as the "Barcelona model". His aim was "sanear el centro y monumentalizar la periferia" (AA.VV., 1995).

For Bohigas, "monumentalize the periphery" meant to provide architectural quality to the suburbs of the city through small interventions and through the building of strategically located monuments, once he was sure that these new presences would increase the quality of public space, and thus, potentially, the quality of life for its users (Balibrea, 2003). It was a progressive conception of space thought for social impact, where re-symbolic significance was able to enter a specific social context and the lives of their poorest citizens.

Although some aspects of these proposals sound paternalistic and obsolete, they started with a much more inclusive knowledge about public space and urban culture than that which would be imposed later on.

One could argue that there existed basically two types of pathology in the city: on one hand the situation of degradation, in the sense of the loss of quality that the fabric of the city had suffered in certain central areas, and on the other hand the situation of the outskirts which, due to several degrees of deficiencies, had not managed to become fully part of the city. In the Barcelona of the late seventies, both pathologies were definitely intense and abundant.

The 1976 urban plan for Barcelona has been built on this dialectic, through a process of successive dynamic equilibriums. If this has been possible, it is no doubt due to the shared objectives which the two

ideologies have. To bring value to – or monumentalize – the outskirts and recuperate the centre is, without doubt, one of the expressions that better sums up the range of objectives that have been present in the urban plan for Barcelona.

In the next chapter, the subject of "public space" will be explored in the context of "modelo Barcelona". In order to fully understand the concept of "modelo Barcelona" and how it is associated with public space, one needs to deepen the knowledge with the help of some fundamental bibliography. The most ideological documents concerning this theme are, on one hand, the General Metropolitan Plan itself, and on the other hand, the texts that Oriol Bohigas provided during his term as Urban services secretary, and in particular the introductory text to the publication "Plans i projectes per a Barcelona 1981-1982" (Plans and Projects for Barcelona 1981-1982) and the book "Reconstrucció de Barcelona" (The Reconstruction of Barcelona). "El Modelo Barcelona: Un Examen Crítico" of Horácio Capel, "Barcelona, un modelo de transformación urbana" of Jordi Borja and "Barcelona, evolución de una ciudad compacta" of Joan Busquets are also considered fundamental. Nevertheless, as can be perceived throughout the text, more bibliography was found to be interesting.

PUBLIC SPACE IN "MODELO BARCELONA"

The so called "modelo Barcelona" is a focal point on Barcelona's XX century urban transformations and a reference to a big part of the western world, like Latin America for example. However, because of the apparent exhaustion of its possibilities, some aspects of the model's interventions, focused essentially on tourism, on the organization of big events and in the incentive of the services sector, now start to be questioned. "Barcelona se convierte en estos afios en ciudad tan atractiva para los inversores como para turistas y congresistas, situándose, por ejemplo, entre las 10 ciudades europeas y las 15 ciudades mundiales que atrae más conferencias y encuentros internacionales" (AA.VV., 1995). Sometimes it seems as if Barcelona suffers from a contradiction: it is very much admired by tourists but not so much by its own citizens (fig.12).

igne!!" posters near the *Rambla.*
ır neighborhoods are becoming
xcess of illegal commerce such
Source: Author (2010).

After Franco, the changing periods of Barcelona can be divided into three stages: the 80's, the 90's and the turning point for the XXI century. Era's which Jordi Marti called: "felices ochenta", "transformación de los 90" and "que vienne el s. XXI!!" (Marti, 2006).

"Felices ochenta"

The year 1975 was the year of change. Barcelona was in a phase of euphoria with the recovery of Catalan identity. With Franco's death and the end of the dictatorship, the first democratic elections emerged in 1979. Many of democratic local governments initiated various policies in order to cover the deficits accumulated during the dictatorship. During this period, architects faced a significant increase of public works. Narcis Serra was elected as the mayor of Barcelona and called the architect Oriol Bohigas to work in the "Ajuntament" as the director of city planning of the urban development sector, thus marking the beginning of the democratic process in the municipal administration.

Meanwhile, in 1976, the General Metropolitan Plan (PGM) (fig.13), considered to be the starting point for the whole renewal of the urban planning process, was approved. This plan gave priority to economic aspects as it tried to make Barcelona one of the more referenced cities of the world, as Capel mentions:

"Durante los años 1980 y 90 los gestores municipales de Barcelona han pensado ante todo en la globalización y en la competencia entre las ciudades a escala internacional, tratando de preparar la cuidad para ello. El objetivo vuelve a ser de Nuevo convertir a Barcelona en la capital del Mediterráneo occidental." (Capel, 2005).

Fig. 13 – "Plan General Metropolitano de Ordenación Urbana". Source: (Capell, 1999)

In addition, the plan targeted two main areas of action, namely a greater incentive to the sectors of services and tourism stimulation. Barcelona invested a lot on its image and international promotion through large infrastructures (Capel, 2005). The city constructed more museums of international standard, concert halls and opera houses, cultural facilities and modern attractions.

This plan also focused on a significant change of land use. It imposed a new legal framework for city planning, and in this sense it also proposed a clear organization of the public spaces, or "systems", as well as a designated amount of land just for public and/or green area (Esteban, 1999).

The first moment of intervention, occurred during the command of Barcelona's urban planner Oriol Bohigas, who, in the years of dictatorship, paid attention to the problems the city was struggling and realized the city's biggest problem: the lack of public spaces. Thus, as explained in the book "Reconstrucción de Barcelona", any intervention was based primarily on the (re)qualification of public spaces or the building of new ones.

Bohigas thought to maximize the city's public spaces throughout the entire urban fabric. First it was necessary to work on the small empty gaps in the existing urban conglomerate, and secondly in the places that were most available in relation to adjacent residential fabric (Busquets, 2004).

The PGM was a starting point for projects that were being developed, adjusted or modified. Firstly, one can consider the projects that were based on a close-up vision of space, and that therefore would cover limited areas – the sector – but that at the same time allow considerations of aspects which are perceptible on a global scale. Among these kind of special projects, the special plans for interior reforms – the PERI – are particularly worthy of note.

The period in which the PERI enjoyed their most important role within the municipal policy – especially in the process of drawing-up projects with public debate – was between 1980 and 1986. This municipal democratization is consistent with a concern to improve the existing city: the recuperation of a city council, that represented the interest of citizens, leads, consequently, to an increased level of self-respect of the citizens as a group, making each cluster more sensitive to the needs of improving the urban environment (Esteban, 1999).

The PERI, developed in many places, was not originally foreseen by the PGM. Sometimes it came from the demands of neighborhood associations that felt that a neighborhood without a PERI would be forgotten, since the PGM was seen as too general.

In a first stage the punctual operations prevailed. Interventions were made in some selected plazas as "sectors of rehabilitation stimulus", with the pretention to "affect" the surrounding urban space. A total of 150 operations of public space recuperation were done on the 1980's (Capel, 2005).

By 1980, the Spanish democratic regime was more solid and the economic situation got significantly better, consequently the unemployment percentages went down. And so Barcelona entered a new *era* and was able to think about more ambitious operations. The historic center, for instance, had significant problems regarding housing and equipment degradation, and, in order to face these problems, policies of big interventions were implemented, directly focused on the urban sprawl. When necessary, entire blocks were destroyed and new streets were opened (Busquets, 2004), like the "Rambla del Raval" or the Plaza in front of the church of "Mercé" (fig.14 and 15).

The project "Rambla del Raval", was included in the PERI-sector "Del Liceu al Seminari": "Potser el de major envergadura és l'avantprojecte de Lluís Clotet i Oscar Tusquets -recollit en el PERI del Raval- del sector «Del Liceu al Seminari», en el qual s'ordena la forma de l'espai públic generat pel rosari d'edificis monumentals desocupats i se suggereixen usos culturals i de lleure col·lectius" (Bohigas, 1986).

These specific town planning and improvement actions inside the city, which included the creation of new squares, parks and public facilities, represented an expression of the urbanistic objectives of the new city council as well as a demonstration of the efficiency of the represented democracy itself (AA.VV., 1995). According to this logic, the PERI was also an instrument for real urbanism compared to the bureaucratic urbanism of figures, standards and impacts. But because of all this, immediate results were often expected. The confidence that the PERI was a rapid solution to all the problems in the urban environment was in the heart of many disappointments that, for some, were really the loss of innocence (Esteban, 1999). Citizens finally realized that there are no easy quick solutions to the reform of urban areas and that these solutions almost always carry with them a high cost, and resources are always limited. Thus, over time, the PERI that had been redefined and readjusted, regained its aseptic instrumental image.

Fig. 14 –Project for "Rambla del Raval" according to the municipal publicity. Source: (Capel, 2005).

Fig. 15 – Example of an area where buildings were demolished in order to make a plaza, in this case, in front of the church of la Mercé. Source: Author (2010).

Until now, a specific type of PERI was being referred to: those dealing with significant sectors of the city's neighborhoods whose initiative generally corresponds to the beginning of the 1980's.

Other PERI's, those of a generally limited scope that had a purely instrumental reach, were not considered. Those, not mentioned so far, are now the more common, having the objective to remodel large areas which are in a clear state of obsolescence.

Nevertheless, the urban sector projects had a leading role in the first stage of democratic urban planning. In addition, projects and actions in public space – squares, parks, the re-urbanization of some streets, etc. – in the period between 1980 and 1982 were the most obvious signs of the will of the new city council for tangible action (Montaner et al., 1999).

As from 1982, with the formalization of the first ideas of the Olympic project, a new order of actions was considered.

"Transformación de los 90"

When presented with the idea of the Olympics, Narcis Serra seized the opportunity, thinking that it could be a good way to get the funds for the water-front renewal, which eventually began in 1986. Bohigas, the director of city planning, as mentioned before, considered that the qualification of the seafront was by this time a structuring point in urban regeneration since it was a completely degraded area. "y se ha creado una nueva imagen altamente valorizada de la ciudad: la apertura al mar es algo más que imagen puesto que es una área polivalente y de uso intensiva." (AA.VV., 1995). "Barcelona, abierta al mar" became the slogan of the 90's, "una obertura que exigeix l'anu Hació de barreres, encara que sigui sacrificant la inadequada soHicitud de grans fluxos circulatoris" (Bohigas, 1986).

This event gave high international visibility to the city. Numerous interventions in urban space were made, including, and perhaps most importantly, the redevelopment of the old port area which resulted in the Olympic Village. Defined by the Metropolitan Corporation, the "Plan de Costes" was approved in 1987, aiming to intervene on Barcelona's seafront.

However, Bohigas realized that the whole intervention couldn't be focused in a single area, and so he defined four main points of intervention that would unite the four city corners (*Diagonal, Montjuic, Vila Olimpica and Vall D'Hebron*) and at the same time structured the traffic lanes (fig.16). It was important to spatially distribute the equipment and structures that would host the Olympic Games. With these interventions one could go around the exterior of the city without disturbing its center. This was also an opportunity to repair and expand the drainage and sewer system (Calavita and Ferrer, 2000), in fact one could say that substantial improvements were mandatory (fig.17 and 18).

There is no doubt that the year 1992 marked a qualitative change in Barcelona's process of urban intervention.

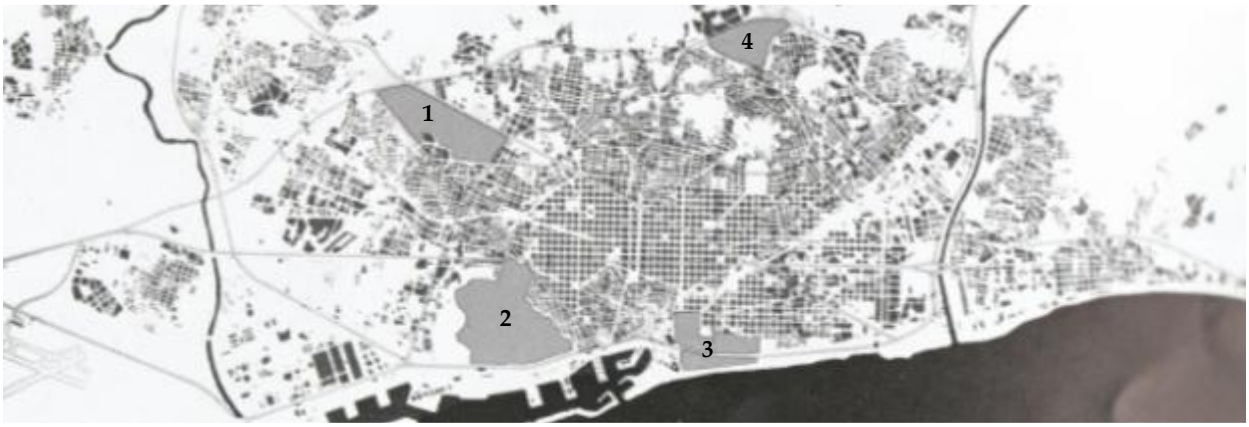


Fig. 16 - The four Olympic areas: 1.*Diagonal,* 2.*Montjuic,* 3.*Vila Olimpica,* 4.*Vall D'Hebron*. Source: Adapted from (Busquets, 2004)

Fig. 17 –The coastal front in 1987: containers from the port on the beaches and sewage draining into the sea. Source: (Mackay, 2000).

Fig. 18 – View of similar spot, transformed, in 1992. Source: (Mackay, 2000).

At this time, the Metropolitan Strategic Plan of Barcelona was prepared, but this was not a pioneer plan as this city had a tradition of plans (from Cerdà until the General Metropolitan Plan, passing through the "Comarca de Barcelona" of 1953).

Some say that this kind of plan is made for cities that are not affected by economic crisis such as Los Angeles. Barcelona's economist Antoni Castells (director of the support commission of Barcelona's economic and social strategic plan) clearly states this idea in his book: "Los Angeles 2000: a Model of Strategic Planning" (1995). According to F. J. Monclús, what differentiates the strategic plans of Barcelona and Los Angeles is that they are both based in a context of economic growth, not in one of crisis. Meaning that this plan is not an antidote but a tool do promote and develop economic growth (Monclús, 2003).

The city's transformation in a focal point for services and in a major destination that attracts 20 million tourists per year demonstrates the success of the strategic plan.

The adopted management strategy involves a public-private partnership that is coordinated by the public administration in order to balance the interests. The privatization phenomenon of places, or simply the exchange of "public space" for "private space", occurs rapidly, at the same pace that "cultural goods" become "cultural products" (Cardoso, 2007).

Capel comments on this "public-private" partnership stating that it is unclear whether Barcelona knew how to manage private interests and, at the same time, public interests in a favorable way for the popular classes (Capel, 2005). In some occasions, this management promoted excessively dense urban area and high-priced housing.

Capel's reflection leads us to the "gentrification" concept, something that happened in Raval's neighborhood. The public-private partnership, which led to major interventions in this neighborhood, forced some residents to leave when they saw their homes disappear with the opening of the Rambla. This urban space requalification made the housing prices extremely expensive, which meant new people to the neighborhood, but of a much different social level than the one existing before. As Josep Montaner (2007) explains, in an opinion article published in "El Pais" newspaper on June 12, 2007:

"La ciudad de Barcelona vive en estos años una continua guerra de baja y no tan baja intensidad contra vecinos y movimientos sociales opuestos a dicho modelo, que impone al desalojo de la población tradicional y humilde de los barrios situados en lo que ahora llaman zonas de nueva centralidad" (Montaner, 2007).

Naturally, any urban renewal process always has social, economic and political implications, mainly by overlapping interests revealed when urban space takes form. But not all renewal processes are negative. According to Capel it is good that there always existed a positive appraisal of the political determination in urban renewal, although he does not cease to refer that there were some actions that deliberately intended to enhance the work of each architect (Capel, 2005), once each had a space to elevate their own work. However, and because there was no link between the several architecture objects or between the spaces to intervene and the city, architectural works of aesthetic value were conceived but most are considered dysfunctional. Logically, this generated large gaps in the urban morphological continuity. Acording to Capel this happened because "En realidad el campo del urbanismo está controlado, tal vez excesivamente, por ingenieros y arquitectos, que desde el siglo XIX compiten duramente por su control. Los primeros definen las grandes infraestructuras, los otros las intervenciones de calles, edificios, zonas libres, áreas verdes. Pero todo ello debería estar al servicio de las necesidades sociales: de la búsqueda de la igualdad, de la equidad, de la disminución de la segregación, del civismo y la educación. Ese es el plan que se ha de debatir en primer lugar para pones luego en marcha las políticas urbanas adecuadas a esos objetivos." (Capel, 2005).

This report aims exactly to shorten that gap between engineers and architects, showing that good relationship examples may exist, examples that conciliate both infrastructure and public space on the behalf of the society wellbeing. The case of the *Dipòsits d'aigües pluvials* could be paradigmatic (cf. chapter 4 – "Case study").

Every city, within the framework of global competitiveness between cities, wants to be a model. And just like New York and Paris, Barcelona also wanted to be a model. It aimed to rise from the industrial ashes

through the "advertising" of an urban development model. The urban policies, developed and implemented in Barcelona since 1980, are what covers this exteriorization and what lead to the formulation of the "modelo Barcelona". This was also achieved through published texts disseminated at national and international level, underpinning the so-called theory of the "Model".

But…. "Que vienne el s. XXI!!"

Today Barcelona is in its third migration wave, which increases the social diversity and brings new challenges related to employment, education, health and housing. "En Barcelona, cambia el mercado de trabajo, la complejidad de las ciudades que se compone substancialmente de bullicio y unos pocos guetos…para ricos, envejece la población con esperanza de vida muy alta, aumentan las persona solas, hay muchas opciones sexuales y muchas formas de vida familiar, la presencia del pobre se realiza en unís ámbitos de la ciudad donde antes no los había" (Fracasso, 2006).

Only recently, people realized that tourists don't go to Barcelona to visit its museums and concert halls - which have no tradition and no collection similar to other counterparts in European capitals - but for the city's public space and the environment they offer.

NOWADAYS

The city now aspires to new projects, in a more comprehensive and larger scale, such as the 22@Barcelona[6] project and the Glories Plaza. But Horacio Capel sees these new urban political strategies more as a marketing plan in real estate development than something that brings benefits to its citizens (Capel, 2006). At the same time, this author is highly critical about this particular model for whom it doesn't go further besides seeking international solutions in models already belonging to the Scandinavian countries and the North American west coast. He refers that nobody thought of an own, native model, Spanish or Catalan, with its traditions, where the industrial history and inherent flexibility of small and medium enterprises, with innovation capability, could be a good foundation for transformation. Still, the same author points out that Barcelona is going through a process of destruction of its social network as it is overly focused on tourism and has its back turned to its historical heritage and people (fig.19 and 20).

The public space depends largely on its form but also on its social movements. Economic competitiveness seeks to make public space a mirror of its interests, creating social exclusion phenomena's and marginalization of society segments that have contrary opinions about the implementation of certain projects (Akiko Okabe *in* (Fracasso, 2006). Public space cannot be used for economic competitiveness. According to L. Fracasso when annunciating Akiko Okabe's opinion, there are other ways to achieve it: "cultural resistance has to stop social exclusion, unite efforts and promote imagination emergence to solve social problems" (Fracasso, 2006).

M. Delgado assumes an even more critical point of view than Capel, stating that it seems like the city, once it hasn't anything else to sell, now sells itself (Delgado, 2005). According to the author, Barcelona is a theme park that treats its citizens as tourists, of which is only expected to admire it, to consume and keep quiet. The city becomes a hostage of big companies, and their project will be defined without considering the population. Once the city is already a "model", according to M.Delgado, what was said before is something to be followed, copied and reproduced.

During a seminar held at Casa Asia in Barcelona called "El modelo Barcelona desde una perspectiva asiática, norteuropea y ciudadana" on March 24, 2006, it was interesting to notice in its minutes how some Japanese wanted to change the whole tradition of the Japanese garden. In order to follow the "Barcelona model" they were willing to lose their identity for something they considered to be innovation (Fracasso, 2006).

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[6] "22@Barcelona project transforms two hundred hectares of industrial land of Poblenou into an innovative district, offering modern spaces for the strategic concentration of intensive knowledge-based activities. This initiative is also a project of urban refurbishment and a new model of city" (*http://www.22barcelona.com*).

Fig. 20 –Interactive exposition in Pl. Nova: The people that passed through could write down and show in a clothesline what they love and hate about Barcelona, everyone was invited. Source: Author (2010).

Fig. 19 - Detail of the interactive exposition: opinion of a person who wished to participate. Source: Author (2010).

According to Josep Montaner, architect and professor at the School of Architecture of Barcelona (UPC), "Modelo Barcelona está agotado" (Montaner, 2007) meaning that the Ajuntament no longer has the power, the clairvoyance and the ability to achieve strong social and urban compensation of private operators, as accomplished in the mid eighties. For Montaner, it is much harder now for the municipalities to attain local control on the urban interventions as its more tempting and profitable to give power to private investors (Montaner, 2007). Apart from this question, the instruments of urban management, *per se*, are already marked by a complicity suspicion or speculation.

Antoni Remesar points out the current "globalization" pressure on public space, stating that it conduces its fate into a continuos privatization, "De la misma manera que existe una globalización finaciera e industrial que se traduce en una libertad total de los flujos de capital, (…) existe también una "onda" de largo alcance que se traduce en la existencia de "modelos globalizadores" de intervención en y sobre el nespacio público que, al igual que sucede en contexto más amplio, supone una galopante privatización del espacio público". According to this hipothesis, he adds a natural concern, the dissaperance of public space, arguing about the problems that migth come if public space is substituded by private place: "…el espacio público es uno de los elementos fundamentales de la existencia de la ciudadanía y de la vivencia de la ciudadanía en democracia" (Remesar, 2005).

In a kind of synthesis, one could consider that there is no settled "model" like a strategic plan, but a new form of planning that is based on the importance and dignity of public space. And in fact this is the basis of all changes in Barcelona after Franco. At the same time, these were very positive changes, especially in the way the city is felt. It is now clear the contribution of this "model" for the rejuvenation of the historic city center and for the living experience of the "new neighborhoods", currently equipped with structures, with their own quality, that symbolize new centralities.

From a philosophical point of view, the difference from the first democratic urbanism projects for Barcelona is a change in the way of conceiving public space (Balibrea, 2003). Public space started to be something belonging to all citizens and that all need and have access – it is a broad definition in our cities full of capitalist inequality, on the other hand it is just a democratic ideal for which, as the major authors cited agree, we should strive.

Much of the success in the national and international perception of "Modelo Barcelona", related to urban regeneration, is based on the interpretation of positive interventions made with public money to create new public spaces for its citizens. Barcelona can congratulate itself for having avoided, until now, the problems particularly associated with U.S. cities in which public spaces, as places for mediation and meeting, are dramatically disappearing (Balibrea, 2003).

However, like M. P. Balibrea mentions, from the moment that, to create public space, public intervention increasingly obeys the institutional relations logic of the local situation of global markets, and not of those institutions with the needs and desires of the local population, the meaning of public space undermines itself and its continued evocation can turn out to be only a rhetorical speculation (Balibrea, 2003).

3.BARCELONA'S FLOOD REALITY

It is important to notice that throughout the planning ages that have been explored in the previous chapters, a subtle urban design existed since Cerdà, in order to better manage the water of Barcelona's extreme rain events. The problem of Barcelona's storm water drainage promoted the development of studies, periodically alleviating the difficulties of an urban evolution. A long-term vision of the future, studies, rigorous works and important decision-making have made Barcelona one of the most well prepared cities in terms of urban drainage problems.

These facts make one think about the possibility of seeing this drainage system and its evolution as an example to export, meaning, as a model itself. It is definitely a "backstage" of all Barcelona's quality and, adding the climate change scenarios, this knowledge can also be the backstage of the future qualities of other cities.

Flash floods are a very common feature in Catalunya and, particularly, in Barcelona. Every year, during the summer or at the beginning of autumn, floods affect the littoral mountains or the Pyrenees region, although sometimes they can also occur in spring. Usually the maximum accumulated rainfall is less than 100 mm, but instantaneous intensities above 180 mm/h were recorded (Llasat et al., 2003).

This was the case of the flash flood events recorded on 2 August 2005 and 20 August 2005 in the Maresme and Vallès, tourist areas "on" or near the coast, and characterized by ephemeral river channels that pass through the villages. In both cases "more than 50mm were recorded in just half an hour and many cars, parked in the littoral water courses, were swept away, while road and railway traffic was interrupted" (Barriendos et al., 2006). Sometimes, however, more than 250mm were recorded in less than 6 h, as in the 25 September 1962 event, when the heavy rainfalls caused overflowing of the Besòs and Llobregat rivers, as well as their usually dry tributaries, and destroyed a complete quarter in Rubí (a town on the NW of Barcelona), producing 815 casualties among 2648 in all Catalunya.

Between 1971 and 2002, the Insurance Compensation Consortium paid 1.574.530.945€ because of floods in Spain, an equivalent to 78.86% of the total insurance money (Llasat, 2008). Floods and droughts, followed by fire, storm and wind and hail stones, are the main natural hazards in Europe.

Scientists also discuss the hypothetical increase in natural risks associated with climate change. While scientific evidence becomes stronger and stronger, registering a significant overall augmentation in the frequency and magnitude on the natural catastrophes, it is globally accepted (even between the skeptics) that these events have amplified its impact not only as a result of increased vulnerability and exposure but also because of the contemporary social perception (cf. chapter "Media and social impact").

MORPHOLOGICAL CHARACTERISTICS OF THE CITY

The city of Barcelona is situated in a Quaternary plain between two rivers, the Llobregat River to the SW and the Besòs River to the NE. The plain is delimited by the coast and the Collserola range (Palaeozoic formation), with maximum altitudes around 500m, and with an area of 120km2. Parallel water courses, coming from a strong slope and with a non-permanent flow, traverse this plain (Fig.21). When heavy rains or a long rainy period arises over or near the city, their overflowing can produce significant damage, like floods, landslides and temporary lagoons (Llasat and Rodriguez, 1992).

Nowadays, most of these water courses are channeled in underground levels and belong to Barcelona's drainage system, being most of them interconnected. This network has been improved in recent years with the construction of underground storm tanks in the city, which will be focused further ahead in this report. As a consequence, heavy rainfall effects over the city are not the same as in the past.

According to Barrera, Barriendos et al., the evolution of Barcelona city, from a consideration of flood risk criteria, can be defined in seven different stages:

1. "BC 200–AD 1250: Natural conditions practically remained throughout the presence of the Roman Empire. Taber hill (16m) was used for human occupation, thereby avoiding flood risk. Barcino, the Roman name of Barcelona, was a small city surrounded by littoral lagoons fed by small temporary

rivers. Therefore, this epoch was a period of no flood risk for Barcino, and thus flood events were not recorded (fig.21).

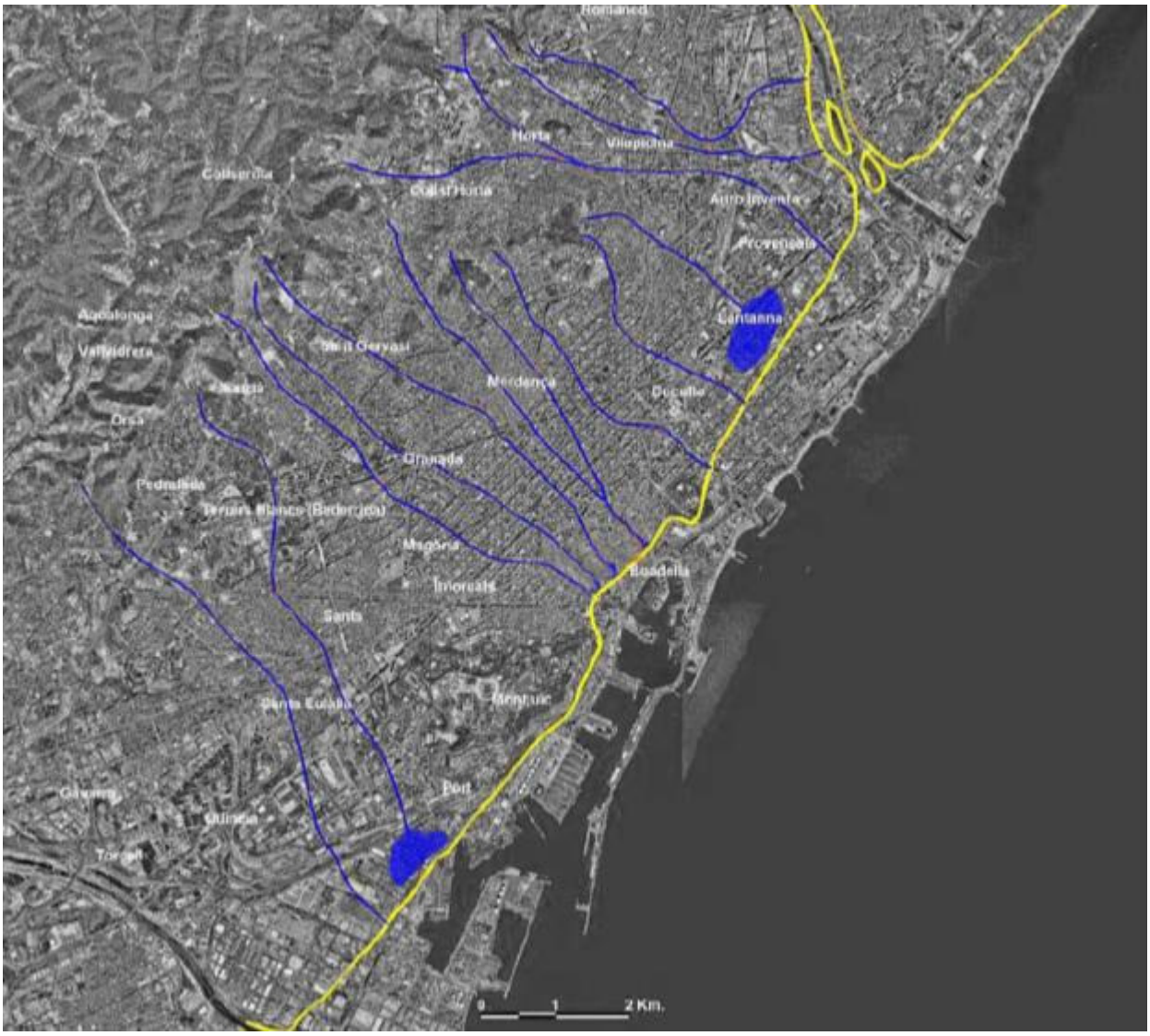


Fig. 21 - Map of Barcelona's hydrographic structure over to a today's ortophotomap. The main names of places and roads and the indication of the coastline reconstruction between the Llobregat and Bessòs between X and XI centuries. . Source: Adapted from (Martí, 1997).

2. 1250–1350: The first flood risk assumptions were experienced in the Early Middle Ages, occupying temporarily flooded areas and littoral lagoons. A open walled perimeter was designed with military function, but also to manage the floods, diverting flows out of the urbanized quarters. Unfortunately, no systematic documentary sources are available for this period. Flood events were not yet recorded (fig.22a).

3. 1350–1550: Major urban growth took place in the Late Middle Ages and a third walled perimeter was constructed. This renewed powerful infrastructure drove water flows into trenches. Flood events were recorded, but most of the damage occurred in this first infrastructure or at the outlet from trenches, close to littoral lagoons. This planning strategy allowed an evident reduction of impacts caused by flooding in the urbanized sector of the city, albeit with limited technology. In the middle of the 14th century the Magòria water course was deflected towards another stream to mitigate the floods produced in the western part of the city when the Magòria overflowed (fig.22b).

4. 1550–1750: The presence of Turkish pirates in the Mediterranean Sea constituted a negative factor for flood situation management in the Early Modern Age. It rendered necessary the construction of a "Sea Wall", enclosing the city completely, because dynamic defense with galleys proved to be

unsuccessful. Large rainfall events producing floods were managed by a combination of walls and trenches with relatively good results. Problems arose with flash floods, when torrential rainfall was recorded into the city itself: a new dam effect was produced by the "Sea Wall" because of drainage limitation (fig.22c).

5. 1750–1850: In the Late Modern Age, the only important changes affected the eastern area, with the construction of a new fortress and the deflection of the fluvial courses in that area. The last remaining coastal lagoons disappeared. Fluvial processes did not change in relation to the previous pattern (fig.22d).

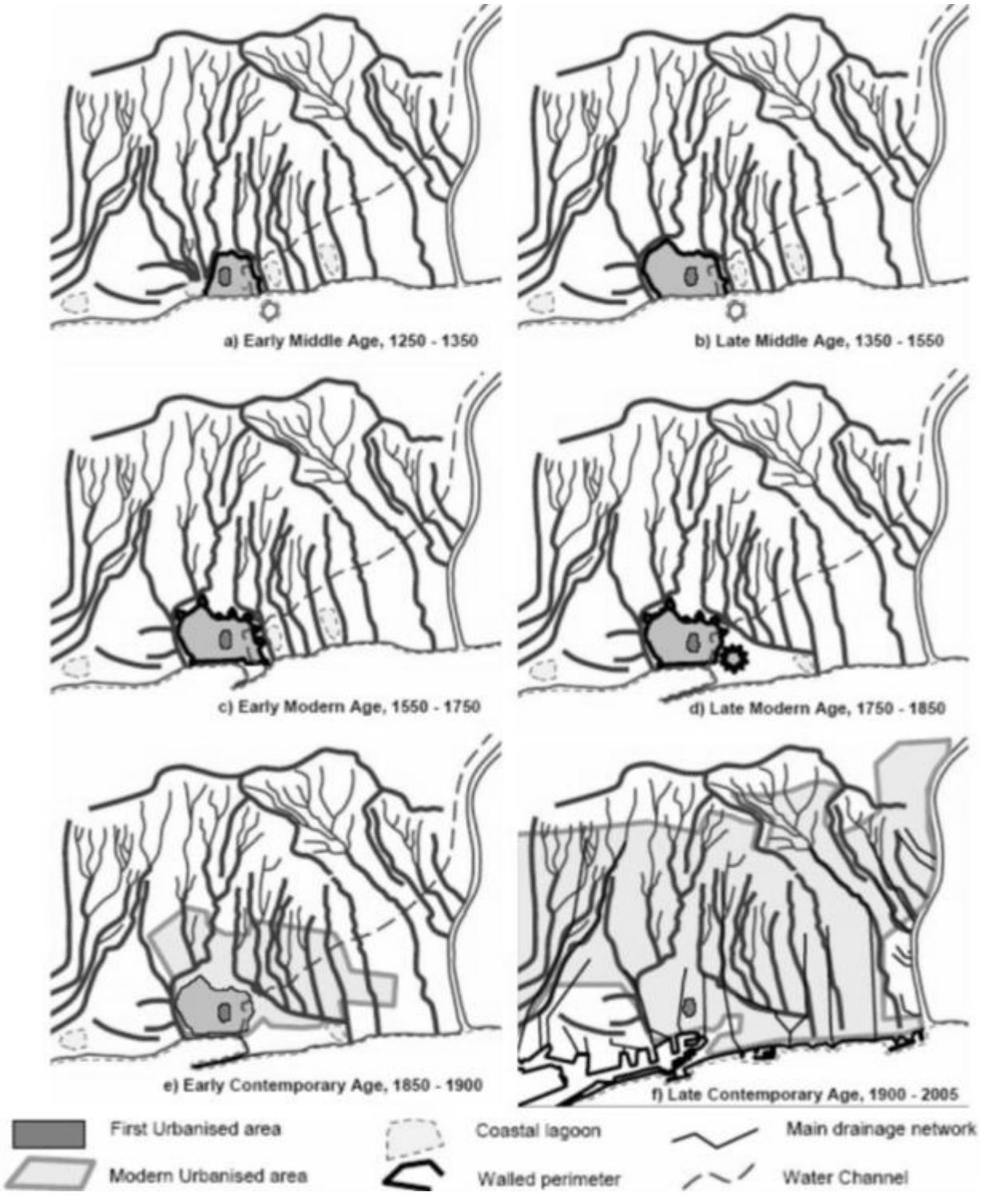


Fig. 22 - Barcelona city urban evolution from the 14th century to the present: (a) AD 1250-1350; (b) AD 1350-1550; (c) AD 1550-1750-1850; (e) AD 1850-1900; (f) AD 1900-2005. Source: (Barrera et al., 2005).

6. 1850–1900: Early Contemporary Age. The traditional protection of walled perimeter was removed during this short period, but was replaced by other operational infrastructure to manage flood events. Barcelona experienced a return to natural conditions with one of the highest human density levels of its history. Most nonpermanent rivers returned to their former beds within or close to the city. This was a great problem for the population, because it had no perception of flood risk inside the city after 400 years of protection by the walls (fig.22e).

7. 1900–21st century: The 1891 drainage network program ushered in a new period of flood risk management. Following different steps (drainage programmes of 1952, 1968, 1988, 1997 and 2004), a new drainage system was organized at underground levels, including pumping stations, storm tanks and a warning system, to manage the flood events affecting the more vulnerable human activities (cf. chapter "Barcelona's reaction to floods reality") (fig.22f)" (Barrera, Barriendos and Llasat, 2005).

But besides the city's evolution, Barcelona has itself a number of characteristics that make the evacuation of rainwater particularly complex. On one hand, the impermeable land area generates large volumes of runoff due to the reduced absorption of the ground. This is said by many to be the most serious problem (Barriendos, Barrera and Llasat, 2006). On the other hand, the topography of the city includes the upper Collserola, a steep slope that doesn't allow infiltration, which softens up only in the bottom plain. Naturally, this topography leads to a rapid concentration of rainwater in the low lands, continuing its flow in slow velocity until reaching the sea.

This is the reason why, when it rains, large accumulations of water are produced in areas under the imaginary division line of Barcelona that is in the Aragó's street (Carrer Aragó), affecting mainly the Poble Nou, Casco Antiguo and Zona Franca (fig.23).

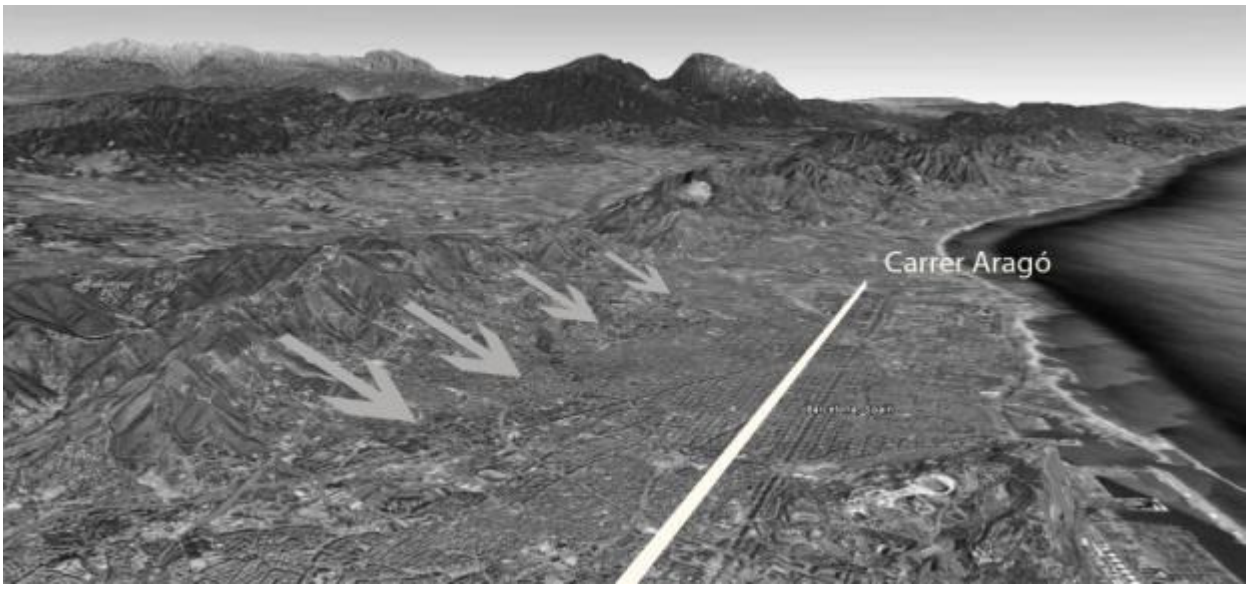


Fig. 23 - Tendency of water flow's direction and location of "Carrer Aragó". The imaginary division line of "Carrer Aragó" divides high velocity and low velocity of water flow – in the areas between this line and the sea, the foods are more frequent. Source: adapted *Google Earth* from Author (2010).

There is also the influence of the urban environment affecting the intensity of rainfall. As we know, the urban environment alters the local climate, originating a "heat island", like what scientists call it, which can lead to differences of up to 10 °C compared to the surroundings of Barcelona's urban agglomeration (Barriendos, Barrera and Llasat, 2006). This effect, combined with others, suggests that convective precipitation processes can be promoted and increased in intensity by the existence of a city like Barcelona.

Another problem affecting the evacuation of rainwater is the fact that most of the water that falls on the upper area of the city has to pass it in order to drain into the sea, encountering obstacles such as the

mountain of Montjuïc, the Casco Antiguo and the Port, which lead to the diversion toward the extremes of Barcelona's coastline.

On the other hand, the phenomena of coastal dynamics and the overlapping of rain with sea storms, with waves over then 6 meters, makes the evacuation of rain water even more difficult, not to mention that low pressures increase sea level up to about 30cm on the coast, which is one more factor that can contribute to the complexity of Barcelona´s rainwater evacuation.

Finally, one must take into account the peculiarities of the Mediterranean climate, especially regarding precipitation, which is characterized by low annual rainfall (between 250 and 1,000 mm). In Barcelona, the annual rainfall is approximately about 580 mm on average, i.e. 580 l/m2, but with isolated episodes of high intensity rainfall (Blanquet, 2004). This kind of convective rainfall, characteristic of the Mediterranean regions, has a significant impact in Barcelona in late summer and early autumn.

The next chapter will focus on the reviewed statistical knowledge concerning the evolution of flash floods in Catalunya.

CHRONOLOGY OF FLASH FLOODS

To have an idea of the temporal evolution of extreme flash floods in Catalunya , the study "Extreme flash floods in Barcelona County" should be explored. And in order to reconstruct the historical flood chronologies, some criteria from A. Barrera, M. Barriendos, and M.C. Llasat, should primarily be acknowledged, like the following:

- "Flash flood": is when a flood is produced by an intense and short rainfall event, as described by observers;
- "Extraordinary flooding" or intermediate flood: is when the flow of the river is sufficient to overflow the usual channel and water is present in the streets or sectors under study. Damage to hydraulic installations adjacent to or in the channel, such as mills, irrigation channels, dams or footbridges can be severe, with partial destruction. This class includes large events, which affect the whole or only a part of the river course.
- "Catastrophic flooding" or large flood: as in the extraordinary case, the river overflows its usual channel. The difference lies in the strength or capacity of the overflowed channel to cause severe damage or complete destruction of infrastructures close to the river or away from the channel (bridges, dams, dikes, walls, mills, houses, drainage systems, irrigation channels, crops, sections of roadways and so on) (Barrera, Barriendos and Llasat, 2005).

Considering these previous information, the reconstruction of floods for the past 655 years has allowed A. Barrera to identify 40 catastrophic floods (47%) and 45 extraordinary floods (53%) since 1351, 64% of which could be considered flash floods (Table 1).

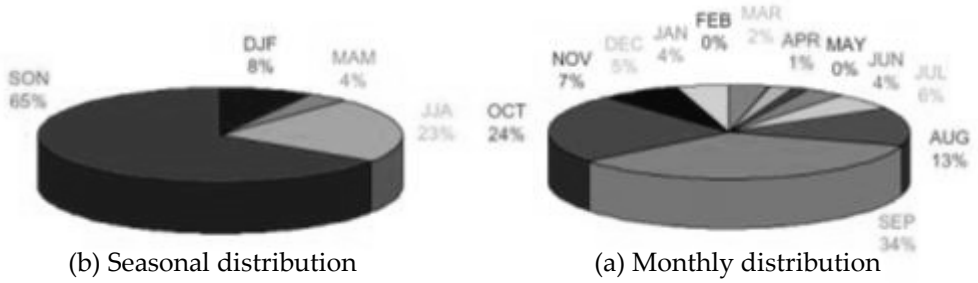
Tabel 1 - Summary of the identified flood numbers for different periods on the basis of the available information: EXT is the number of extraordinary floods; CAT, the number of catastrophic ones and FLASH, the same for flash floods. The last two columns represent the number of days with daily precipitation ≥ 50mm (left one) and the number of those days that recorded a flood in Barcelona city (right one). Source: (Barriendos, Barrera and Llasat, 2006).

Period	No. of floods	EXT	CAT	FLASH	No. of days with ≥ 50mm	
					Total No.	With flood
1351–1853	35	4	31	18	-	-
1854–1900	21	15	6	13	53	21
1901–2005	29	26	3	23	123	29
TOTAL	85	45	40	54	176	41

Seasonal distribution (Fig.24a) showed that autumn, followed by summer, is the season with the highest number of floods, and September (29 cases), followed by October (20 cases), is the month with the highest

record (fig.24b). September also showed the greatest number of flash floods, with 34% of the monthly total.

Figure 25 shows the number of floods recorded from 1351 to 2000, for 50-year periods. The number of flash floods for each period is also included. This figure provides information on the evolution of flood occurrence in relation to climatology and on the evolution of vulnerability.



(b) Seasonal distribution (a) Monthly distribution

Fig. 24 - Flood distribution: (a) seasonal and (b) monthly. Source: (Barriendos, Barrera and Llasat, 2006).

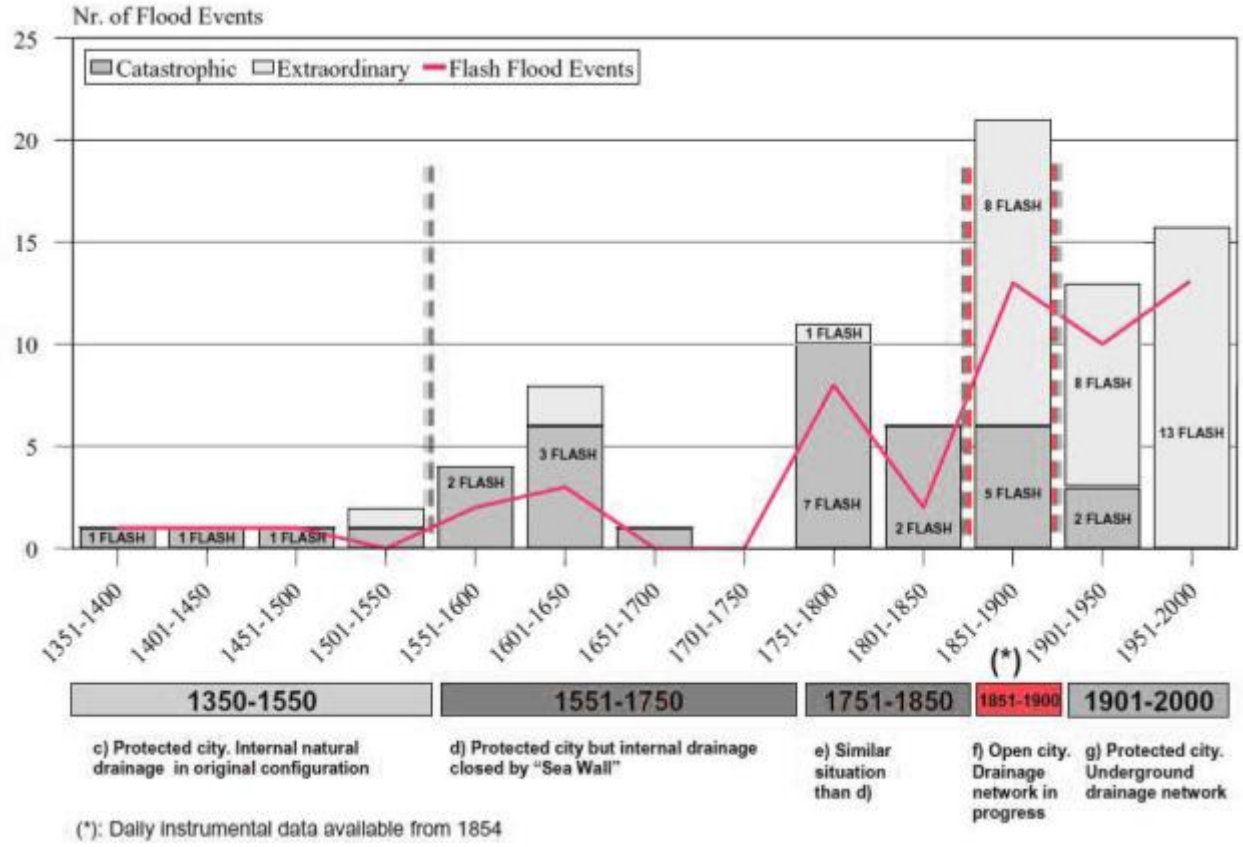


Fig. 25 - 50-year period flood distribution in Barcelona from AD 1351 to 2000. Source: Adapted from (Barriendos, Barrera and Llasat, 2006).

Some climatic oscillations can be observed in the early and late modern-age periods: some periods of an increasing frequency of events (i.e. 1601– 1650, 1751–1800, 1851–1900), while other longer periods show a lower occurrence of floods (1651–1750). Besides this, the evolution of flood occurrence shows an increase of extraordinary events in conjunction with an increase of flash flood events over the last 150 years.

After five centuries of relatively low vulnerability, in which only extreme events affected the city and destroyed external walls, Barcelona experienced a short period of 50 years (1851–1900) with an abrupt increase of vulnerability and extraordinary events. Actually, it was a collective human decision, preferring rapid and complete destruction of the walled perimeter before planning and construction of pertinent networks for the various services including drainage had been addressed (Barrera, Barriendos and Llasat, 2005). The increase of extraordinary events, practically unknown during the Middle and

Modern Ages was simply the result of the abrupt change of environmental conditions: a 19th century industrial city was converted over the course of 50 years back to natural conditions like those of 2 000 years earlier but with a much larger population.

Summarizing in one sentence, although the number of catastrophic flash floods has diminished, the extraordinary ones have increased.

What if we consider, adding to the information so far, the impacts of climate change? Does the situation improve or does it get worst? Are Catalunya and Barcelona aware and ready for the eventual consequences that scientists predict for our future climate? The next chapter will focus on the answer to these questions.

ADDING CLIMATE CHANGE IMPACTS

Despite the known uncertainty of long term forecasts, the 4th Assessment Report (4AR) of the IPCC (Intergovernmental Panel on Climate Chang) is already based on an important analytical basis *verified* and not only estimated. In fact, direct observation of changes to the current climate allowed the IPCC to affirm that the heating of our climate system is unequivocal, evidenced from the increasing global temperatures of the air and of the ocean, melting ice and snow and regular sea level rising.

In the same report (4AR), it is clear that the impacts of climate change will differ among regions. Also, as well as in several other bibliographical references (ACA, 2009; Bladé et al., 2010; Cantos, 2009; Cunha et al., 2008; Santos et al., 2002; Santos and Miranda, 2006), it is also recognized that the Mediterranean region and the whole south of Europe are amongst the regions that will suffer the biggest impacts – and one of them is associated with the widening of Europe's regional climatic differences.

Summarizing the bibliographical review made for this paper's chapter on Climate Change in Europe, as temperatures increase, Southern Europe's reserves of water will decrease. At the same time, in the warm and arid interior areas, agriculture and tourism will require more and more water. The risk of rain storms within each region will be higher and so the flooding will be more frequent. The risk of pollution will get bigger with floods once they will induce emergency discharges of water treatment deposits. Because of the sea level rising and of the more frequent storms it is also predicted that erosion in littoral areas will increase. Finally, it is also assumed that, because of the increase of water temperatures and decrease in river flows, the quality of water will be affected (IPCC, 2007).

Spain already designed the "Plan Nacional de Adaptación al Cambio Climático" (OECC, 2006) that contemplates structural and territorial planning measures in order to react to the possible effects of climate change in the near decades.

Nevertheless, Spain's existing climatic diversity implies detailed regional analysis, especially in the Mediterranean coast, where irregular pluviometric focal points can imply significant differences in the total number of episodes of flood between the different regions. That's why Catalunya worked on the report "Aigua i canvi climàtic - Diagnosi dels impactes previstos a Catalunya" (ACA, 2009).

Regarding the climate projections for Catalunya, in ranges of temperature and precipitation based on current knowledge and modeling techniques used by the researchers in charge, table 2 summarizes the report's conclusions.

As can be seen, the expected forecast until the end of this century, corresponding to the A2 scenario (fig.26), shows an increase of temperature and precipitation variation. The column on the right, with the estimates of changes in temperature and precipitation for the next decades (2011-2040), is valid for all scenarios (A1, B2, A2, B2) once this horizon is very close and so the projections for different scenarios are virtually indistinguishable.

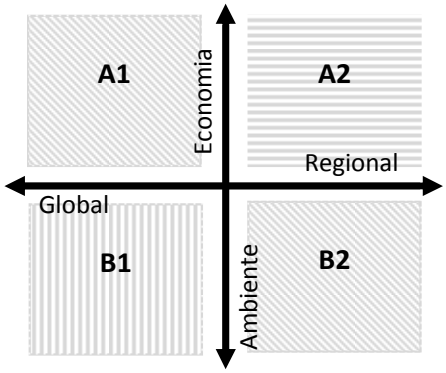


Fig. 26 - Illustration on the significance of the different kinds of scenarios. Source: Author (2010).

Briefly, it is observed that the average temperature of Catalunya could rise between 4 and 5.5 degrees by the end of the century and that this increase is much more significant in summer, especially in the Pyrenees and inland areas (up to 7°C), and more mild in winter, especially in coastal areas (around 3°C).

Concerning precipitation, for an annual average, it may decrease between 5 and 15%. The summer season will be the one that can most "suffer" with this significant drop of rainfall (up to 40% precipitation coastal areas). Moreover, in the area of the Pyrenees and in the wettest seasons like autumn, the decline in rainfall will be more moderate.

Tabel 2 - Temperature increase (upper line in °C) and climatic change in percipitation (bottom line in %), estimates from papers and documents reviewed in (ACA 2009).

	A2 scenario, 2071-2100 period					**All scenarios, 2011-2040 period**
	Winter	**Spring**	**Summer**	**Autumn**	**Year**	**Year**
Cost	2.5-3.5	3.0-4.0	5.0-6.5	3-15,	3.5-5.0	0.4-16
	-10.0	-10	-60	-15.5-5.0	-30	-12.0
Interior	2.5-4.0	3.5-5.0	6.0-7.0	4.5-6.5	4.0-5.5	0.8-2.0
	15	-20	-50	-20	-20	-2
Pyrenees	2.5-4.0	3.0-4.5	6.5-7.5	5.0-6.0	4.0-5.5	0.8-2.0
	20	0, +10	-15.0	-10.0	0	8
Catalunya	2.5-4.0	3.0-4.5	5.5-7.0	4.0-5.5	4.0-5.5	0.7, 1.9
	5	-10.0	-40	-20	-20	-2

It is interesting to notice that although the major bibliography reviewed on the impacts of climate change, for Europe (Bates et al., 2008; EU, 2007; Nordregio, 2007), the Iberian Peninsula (Bladé, Cacho, Castro-Díez, Gomis, González-Sampériz, Miguez-Macho, Fiz, Rodríguez-Fonseca, Rodríguez-Puebla, Sánchez, Marcos, Valero-Garcés and Vargas-Yáñez, 2010) or even for Portugal (Santos, Forbes and Moita, 2002; Santos and Miranda, 2006), mentions the great possibility of extreme events increase (both droughts and rain storms), in this official (government wise) Catalunya's report on climate change it is only considered the increasing temperature and decreasing precipitation, thus not including the stronger rain storms and its consequences.

Obviously, this does not mean that the future changes in climate will be different in Catalunya compared to any neighbor region. Most certainly, the main reason why Catalunya is not considering extreme rain events in the official climate change reports, policies and strategies for adaptation, is that unfortunately this is already a well-known fact for the region, considering the countless disasters by now occurred. In fact, the "Pla Especial per Inundacions a Catalunya (en revisió)" does not forget the most important years of floods and their consequences: 1863, 33 deaths; 1874, 600 deaths and 700 homes destroyed; 1907, 29 deaths and 110 homes destroyed; 1940, 90 deaths and 380 homes affected; 1962, 700 deaths; 1971, 35 deaths and 450 affected factories; 1982, 6 deaths and in 1994, 10 deaths (INUNCAT, 1997)

So the question is: does Catalunya not consider the extreme events, and its increase in power and frequency? Is Catalunya only worried about "mitigation" (reduction of CO2 emissions) and not "adaptation" to the predicted scenarios (fig.27)?

As it will be clear in the following chapters, the answer is no. Catalunya simply divides the responsibilities in different government institutions (cf annex I), being the "Oficina Catalã de Cambio Climático" responsible for the "mitigation" and the "Agència Catalana de l'Aigua (ACA)" and the "Direcció General de Protecció Civil (DGPC)" responsible for the adaptation.

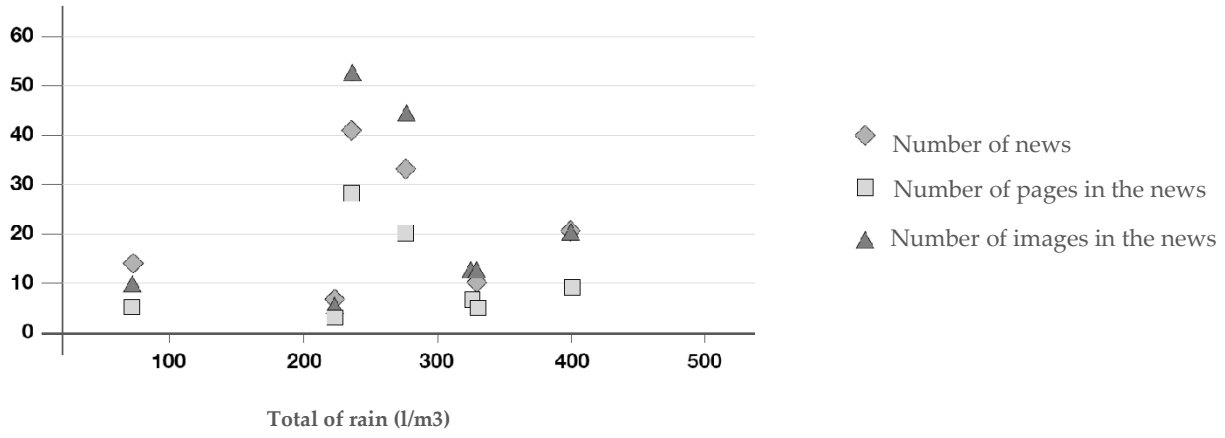
Fig. 27 - Sign outside some metro stations in Barcelona. Source: Author (2010).

MEDIA AND SOCIAL IMPACT

The press is a good way to measure the social impact of the events associated with natural disasters and climate change. On this matter, in "Teoría General de la Urbanización de sus Principios y Doctinas a la Reforma y Ensanche de Barcelona" of 1867 Cerdà furthermore observes "Apenas pasa otoño ó invierno, sin que la crónica periodística anuncie con sus mil bocas, catástrofes como las que venimos reseñando, acaecidas en urbes de primera categoría. Y cuenta que de estas se habla, no porque sean las imitas que tales catástrofes sufren, sino porque son las que llaman principalmente la atención de los estadistas, que no saben ver la humanidad más que en esos grandes centros." (Cerdà, 1867).

For most of the population it is the most reliable source of information about these events and, consequently, the social level of knowledge and awareness is heavily dependent on the type and content of the news. On the other hand, it is considered adequate (validated by the scientific community) to use the press to produce a type of statistic (Llasat, 2008). H. W. Fisher, for example, shows that the degree of accuracy of the perception of what happens before, during or after the disaster or risk depends on what the media says (Fisher *in* M. C. Llasat 2008). According to G. Codrón and S. Cervera, also the idea that the local natural disasters, which always exist in a region, are increasing due to climate change is also significantly influenced by the press and television (Codrón and Cervera, 2000).

According to M. C. Llasat, the news on floods usually refer to the impacts of rain, flooding of rivers and streams, flooding *in situ* and other risks that may develop due to heavy rains or parallel events like landslides, wind storms, thunderstorms, and (less times) tornadoes or hailstorms (Llasat, 2008).



orded in Catalonia between
Llasat, 2008).

In the last 30 years, the episodes that have occupied more space in the press have been November 1982 and June 2000 (Llasat, 2008). But as figure 28 states, there is no correlation between the impact of the news and the severity of the rainfall incident from a meteorological point of view. For example, comparing with the year of 1982, it was the episode in June 2000 which had the greatest impact in the press, with 52 images and 41 news.

On the other hand, figure 29 shows an example of the impact that may occur in the press and how this can introduce a reflection on its social impact. The events of October 2005, April 2004 and October 2000, with a maximum rainfall of 393, 321 and 319 l/m2, have lower values of press data than the events of September 2006 (267 l/m2) and June 2006 (224 l/m2) that didn't reach half the impact.

The study of the evolution of the news of floods and landslides in the past 25 years confirms this trend of growing media attention (Botija, Llasat and López, 2007).

Figure 30 shows the evolution of the floods that are discussed in the press since 1982. A significant growth can be observed in recent years, with a maximum between 2003 and 2006, which is not justified by a real increase of flood and so, like M. C. Llasat states, it is probably caused by an increase in perception and a decrease in the threshold of tolerance (Llasat, 2008). In fact, in Catalunya, since 1982 the most disastrous flood events were recorded in November 1982 November 1983 October 1987 November 1988 October 1994 and June 2000 (Llasat, 2008).


MARRUECOS NOMBRA PRIMER MINISTRO A UN TECNÓCRATA • PÁG. 8

LA VANGUARDIA

Caos tras la lluvia

Graves inundaciones y zonas incomunicadas en el Baix Llobregat y el Garraf

Atascos kilométricos y conductores atrapados en los accesos a Barcelona

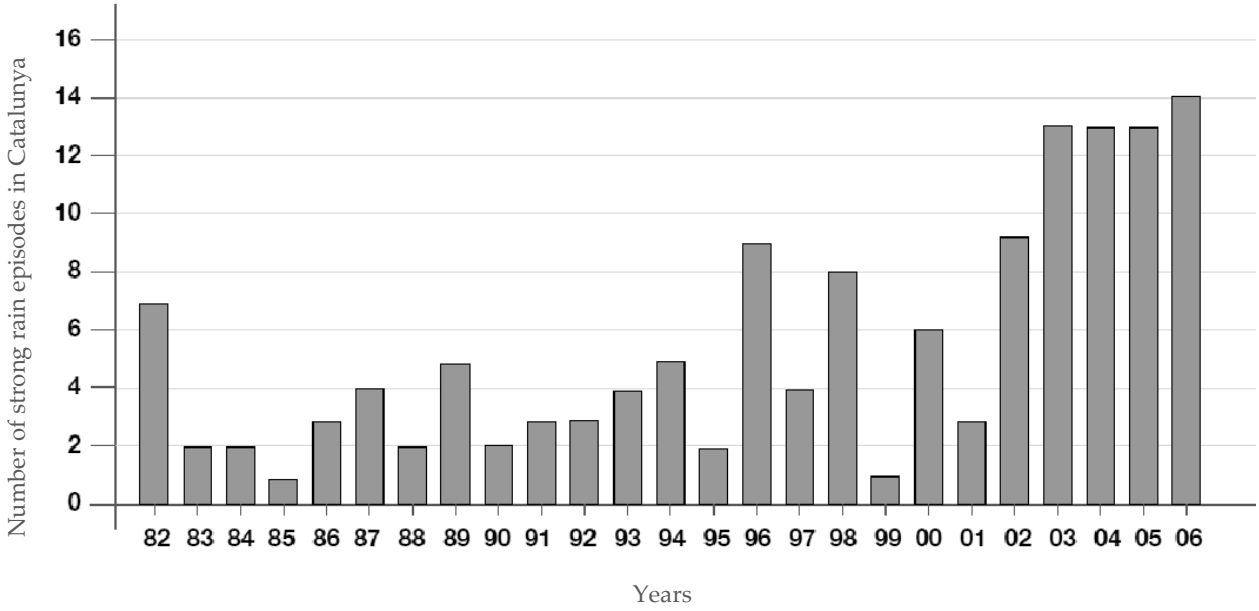
La previsión es que las precipitaciones puedan intensificarse el día de hoy

AUTOVÍA ANEGADA

208 vuelos cancelados al inundarse el centro de control aéreo de El Prat

SIN CUOTA

newspaper fontpage from the
Source: SINC (Servicio de
Científicas)



rs. Source:(Llasat, 2008).

However, from 2000 to December 2006, 10 floods with serious consequences were recorded in Catalunya, with damages above the 155 M € (Botija, Llasat and López, 2007).

What these scientists conclude is that the material impact is growing due to increased vulnerability. M. C. Llasat even shows the difference of the amount that the Insurance Compensation Consortium paid for

the flood episode of September 2006 (€ 55,993,194) and the amount paid for all episodes recorded in 2005 (€ 59,892,409) (Llasat, 2008).

Summarizing, according to the bibliographic review for this report, the increase in news about floods recorded in the last decade corresponds to an increase of documented episodes in the press rather than an increase in new episodes.

On the other hand, the news related to climate change are increasing, both regarding the number of documented events as by new events. Also, Tábara states that "empirical research have shown that there is a significant correlation between public perceptions of complex environmental issues - that people tend to see very far or linked to their everyday problems - and their appearance in the press" (Tàbara, 2005). An immediate conclusion makes this growth correspond to a greater social concern about climate change, fueled both by good results in science and for intuitive associations, which are not necessarily correct, that unequivocally relate climate change to increased natural hazards.

Nevertheless, there is no doubt that there is a positive trend which, above all, indicates a greater perception of situations that went formerly unnoticed and that, according to M. C. Llasat can be justified according to four factors (Llasat, 2008):

- A decrease of the tolerance thresholds of the people involved, who now consider extraordinary situations that were once accepted as ordinary;

- Increasing the amount of information in all areas related to environment and natural hazards;

- Increased losses associated with both an augmentation of the population in areas of flood risk and to the bigger value of the materials exposed;

- Increased social mobility that leads to an ignorance of the environment and exacerbates the reckless actions.

BARCELONA'S REACTION TO FLOODS REALITY

In order to fulfill part of the specific goals mentioned in the beginning of this report, the planning strategies for the frequent floods, characteristic of Barcelona's geo-morphological situation, will now be analyzed.

As seen before, even if we don't count the probable impacts of climate change, the city of Barcelona has a number of characteristics that make it particularly complex to evacuate rainwater, like for example: a natural climatic situation that promotes frequent extreme rain events; a high percentage of impermeable land area that reduces the water absorption in the ground, and the inherent city's topography that, because of the upper Collserola, leads to a rapid flow of the water (also not permitting infiltration) that only concentrates in the low lands.

Some say that, because of the long-term vision of the future applied in studies, rigorous works and important decision-making, Barcelona is nowadays one of the best prepared cities in terms of urban drainage (Blanquet, 2004).

Cerdà was within the discussion process about the urban infrastructures services of Barcelona's Eixample, especially the sewage system. He even developed a kind of solution that articulated the new social requirements of the technological revolution, proposing a utility tunnel with appropriate sanitation systems, water supply, gas and telegraph, which were fully connected to the streets and housing (Torner, 1995).

However, due to the liberal nature of Cerdà's planning proposals, where he outlined general principles to be followed and shared elements on how to build the new city, Cerdà didn't submit a graphical sewerage network proposal in the "Proyecto de Ensanche" of 1859.

Only in 1863, for the presentation of "Anteproyecto de Docks de Barcelona", Cerdà is forced to define a sewage network compatible with the proposed underground rail network.

Finally, the extensive deployment of these works will only occur years later, and his railway network and sanitation project would not be executed. However, Cerdà intervened directly or indirectly in the initial stage of implementation in the residential area of the Eixample in Barcelona. Initial stage from which Pedro Garcia Faria picked up from, proposing a new plan thirty years later.

So in 1891, the civil engineer Pere Garcia i Faria wrote the first "Plan de Saneamiento de Barcelona" primarily with a hygienist criteria in which the main objectives were the epidemics eradication and the recovery of the public use of beaches (Cid, 1974).

In 1952/1954, and using the "Sanitation Plan of Barcelona" as a guideline, another plan was developed: the "Plan General de Saneamiento y Alcantarillado de Barcelona". In this plan, major deficiencies in the existing network system where firstly identified: like the general lack of capacity, the water concentration in only three sea drain points (Sants collector and the streams of Horta and Bogatell), the lack of wastewater purification, the need to connect all buildings to the a sewer system and the problem of low slopes, which produced abundant deposits in the sewers of lower zones (Blanquet, 2004).

In the 60's and due to a large immigration wave, Barcelona suffered a strong urban development which led to an intensive growth and densification of the city. As a result, the impermeable surface increased and many collectors failed to absorb the new amount of water during flood times. This situation, coupled with the growing economic importance of many flood-prone areas, raised the interest in a new study focused to solve the existent problems and to foresee the future.

Thus the 1978 "Plan de Alcantarillado", led by the civil engineer Don Albert Vilalta González and written by the "Servicio de Alcantarillado del Ayuntamiento de Barcelona", arose (Mackay, 1999).

Vilalta's Plan placed particular emphasis on the drainage of rainwater and purification of waste water and, for the first time, a rigorous calculation methodology was used. The plan specifies a series of actions such as: the reuse of water for irrigation and industrial uses and the restoration of some rivers to its natural discharge areas, for example by discharging the output of Bogatell; and the interception of direct outputs of sewage into the sea, leading those waters into water-treatment facilities and thereby ensuring the quality of marine waters on the beach for recreational use by citizens (Blanquet, 2004).

For M. Blanquet, the idealization and plans for the treatment facilities of Bogatell and Besòs are the most important achievements of Vilalta's Plan. In fact, although the plan was incomplete in its implementation, due to lack of investment, their fundamental approaches have been used for subsequent plans. The problem of the disposal of storm water started to be a strictly municipal affair and in 1981 the "Plan Especial de Saneamiento Metropolitano" was wrote, specially emphasizing the regeneration of coastal shoreline and reuse of treated water from a metropolitan view (Mackay, 1999).

In 1988 the municipality developed the "Pla Especial de Clavegueram de Barcelona" (PECB), set for horizon of 25 years (until 2013), which consisted of two main studies: the analysis of network performance and the promotion of actions aimed at the definitive resolution of the existing flooding problems[7]. The PECB was developed considering the urban conditions imposed by the consolidated development of the "Plan General Metropolitano", including the existing projects and management of urban spaces intended for the Barcelona Olympics of 1992. Without going into details, the plan´s main criteria included the determination of a 10 year return period, the spatial and temporal consideration of rainfall distribution, the analysis of the data from direct observations and autonomous work of the whole system (Donadeu, 1996). This plan mentioned, for the first time, the possibility of implementing a pilot system that would control the sewage network in real time as well as the construction of regulation reservoirs to avoid the need to duplicate the collectors and to have room for a lot of water in case of major flood. The first point had already been achieved and the second was about to be complete.

[7] Although this was a municipality job, the analysis of the network was comprehensively addressed, including Barcelona´s drainage network as well as the drainage network of the surrounding municipalities that form part of the hydrological area: Hospitalet, Esplugues and part of Sant Adrià.

Later, and before hosting the 1992 Olympic Games, the company "Clavegueram de Barcelona, SA" was created, with the participation of private partners such as "Sociedad General de Aguas de Barcelona, SA" and "Fomento de Construcciones y Contratas, SA" who would provide the technological, financial and business strength, in addition to the historical knowledge of citie's sewage system. As a result, and regardless the normal evolution of works developed in a big city, it was initiated an evolutionary process of advanced planning and management of city drainage that includes real-time information about sewer network behaviors through computerized support systems, remote supervision, remote control facilities and the modeling/simulating the network's operation – all of this based on a rigorous methodology[8].

Naturally, and considering the future changes that Barcelona was expecting over the following decade (large urban changes tied to the "Plan Delta del Llobregat", the opening of the Diagonal to the sea, the "Plan Sagrera Sant Andreu", the TGB, the "Plan Congost del Besòs" and the "Fórum de las Culturas" of 2004, the plan had to be reviewed, resulting in the "Plan Especial de Alcantarillado de Barcelona" (PECLAB) of 1997 (Blanquet, 2004) (cf. fig. 36 in chapter "Case study").

The highlight of PECLAB's actions was the construction of, so far, eleven regulation tanks (this report's case-study - cf. table 3 in chapter "Case study") that will avoid large accumulations of water in certain areas when major floods occur, retaining storm-rain-water long enough to subsequently evacuate it little by little, thereby also achieving further depuration and thus improving the environment. These particular regulation deposits are studied in the next chapter.

On August of 2006, in order to help the municipalities to adopt appropriate measures in the field of civil protection against floods, the INUNCAT ("Plan Especial de Emergencias por Inundaciones de Cataluña"), promoted by the Civil Protection Department of the Generalitat de Catalunya (DGPC) and written by "Agència Catalana de l'Àigua" (ACA), was approved by the Government of the Generalitat de Catalunya (ACA, 2010). The main objective of this plan is to deal with flood emergencies within the territory of Catalunya through warning systems, organization and operating procedures of the services of the Generalitat de Catalunya, the government and other private entities. Although the plan does not consider all the streams and rivers of Catalunya, it gives a very complete and comprehensive flood hazard analysis.

Three specific maps, that configure Barcelona city's area, from the "Delimitació geomorfológica de zones potencialment inundables" of the "Delimitació de Zones Inundables per a la Redacció de L'INUNCAT", were joined together in fig.31 (the original respective maps can be seen, in A4 format, in annex II). As can be seen in figure 31, the "Zona potencialment inundable" in light blue, comprehends a very significant percentage of Barcelona city.

Besides the INUNCAT, and at a local level, the "Planes de Actuación Municipal" (PAM) para inundaciones" are the mean to define actions, providing control to a particular town in an emergency due to flooding. So far there are no PAM's, nevertheless, as INUNCAT indicates, for the region of Barcelona city, they are mandatory.

In the medium scale, between INUNCAT and PAM, there is the Plan of "Planificación de Espacios Fluviales de Catalunya" (PEFCAT) which is one of the most ambitious projects of the "Agencia Catalana del Agua" (ACA) for a detailed analysis of Catalunya's rivers, taking into consideration all stakeholders. In this case, ACA has developed a methodology based in the analysis of the rivers processes and their behaviors, working with multidisciplinary groups that promote a comprehensive vision[9].

[8] cf. *http://www.clabsa.es/*

[9] *in http://aca-web.gencat.cat/aca*

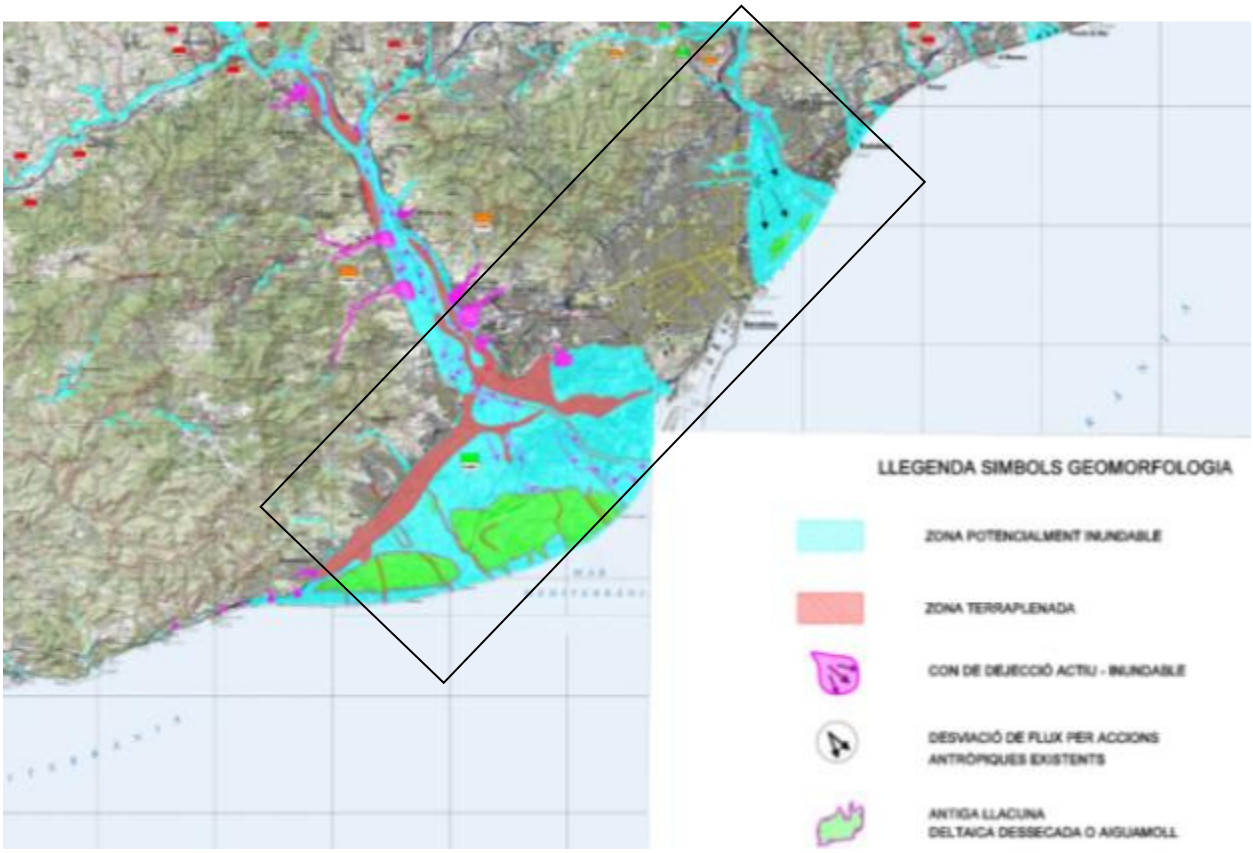


Fig. 31 – "Delimitació geomorfológica de zones potencialment inundables – INUNCAT": Three specific maps, that configure Barcelona city's area were joined together in this figure. Source: Adapted from (ACA, 2010).

Fig. 32 – "..zones potencialment inundables" of Barcelona city - detail of figure 30. Source: Adapted from (ACA, 2010)

4. CASE STUDY: 'DIPÒSITS D'AIGÜES PLUVIALS'

As mentioned in this report's methodology, an exhaustive study on Barcelona's "Dipòsits d'aigües pluvials" was made in order to accomplish the goals initially proposed. Recalling, the research was essentially divided in two parts, a first part that will focus on the characteristics of Barcelona's particular sewage system (what kind of system it is, what are the tanks for, who designs the deposits, who controls the system, who paid for the deposits, etc) and a second part that will focus on the particular identified duplicities between 'infrastructure' and 'public space'.

A 6 days field trip was required in order to fulfill the expected knowledge about each specific deposit. These field trips allowed not only the identification of their exact location and configuration but also an exhaustive photographic survey of the existent spaces on their surface (cf. annex III).

SEWAGE SYSTEM

Many cities that installed sewage collection systems before the 20th century use single-pipe systems that collect both sewage and urban runoff from streets and roofs. This type of collection system is referred to as a "combined sewer system" or a "CSS". The cities' rationale when these systems were built was that it would be cheaper to build just a single system (Burian et al., 1999). Most cities at that time did not have sewage treatment plants, so there was no perceived public health advantage in constructing a separate storm sewer system.

This type of sewer design is no longer used in building new communities, but many older cities continue to operate combined sewers. Nowadays, in new urban zones separated sewer systems are the ones to be implemented, consisting in separate sewers for sanitary and storm water flows. In these separate systems, storm water is conveyed to a storm water outfall for discharge directly into the receiving water. For example in Lisbon's case, the old part of the city (form 'Campolide' to 'Baixa Pombalina' and from 'Ajuda' to 'Santa Apolónia') still have CSS but new separate systems where built in the low areas (waterfront from 'Algés' until 'Belém') and in the new urbanizations (Olivais and Benfica) (Matos, 2003).

Most of Barcelona operates with combined sewer and so in dry weather and during light to moderate rainfall, the system is able to convey all flows to the wastewater treatment facility. During periods of heavy rainfall, however, the capacity of the CSS can be exceeded, often causing untreated combined sewage and storm water to back up into basements and to overflow from manholes onto surface streets. Traditionally, CSS outfalls were designed to discharge directly into receiving waters during combined sewer overflows (CSOs). This was done to prevent the excessive combined flows from directly impacting public health via basement and street flooding. As a direct consequence of the CSOs, these combined sewers can cause serious water pollution problems due to the combined sewer overflows, which are caused by large variations in flow between dry and wet weather (fig. 33).

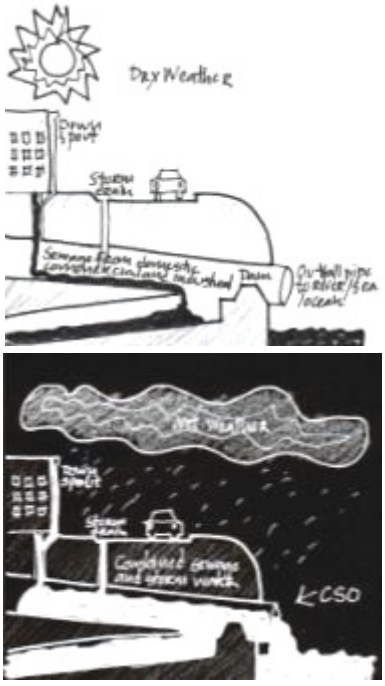


Fig. 33 – Graphic representation of what is a CSO: the discharge of wastewater and stormwater from a combined sewer system directly into a river, stream, lake or ocean.
Source: adapted from: http://water.ky.gov/permitting/Pages/CombinedSewerOverflows.aspx

As cities added sewage treatment plants, relief structures were installed in the collection system so that the flow could be discharged into a river or stream during large storm events when the capacity of the pipe exceeded the capacity of the wastewater treatment plant. By using these devices called 'regulators', to discharge the excessive flow into a nearby water body, sewer backups in homes and streets were prevented.

Naturally, also Barcelona's sewer system needed an effective flow regulation in order to avoid CSO's and protect the treatment plants from the flow variations, improving their performance. For this purpose,

several retention tanks were built, in order to store the combined sewage during heavy rainfall episodes. In summary, the rainwater-retention tanks include the following two functions: 1) The accumulation of vast quantities of water during heavy rainfall episodes to avoid its circulation through the drainage network at the most critical moments - the tank's retention volume allows a flow lamination in such a way that its maximum outflow is significantly lower than the inflow, having obviously positive effects on the downstream drainage network that will be considerably less overloaded; 2) The reduction of the outflow into the beaches, rivers and harbor of highly contaminated rainwater with solid material suspended - after being retained in the tanks, this water has a lower degree of contamination due to the sedimentation and is released slowly to the treatment plant.

As mentioned in chapter "Barcelona's reaction to floods reality", these tanks are a part of the 1997 "Plan Especial de Alcantarillado de Barcelona" (PECLAB) and were constructed by CLABSA (Clavegueram de Barcelona, S.A.). As can be seen in figure 36, that confronts the existing thanks to the 1997 PECLAB, not only some planned tanks are still to be constructed but also some of them slightly changed location[10].

CLABSA performs advanced management (planning, monitoring and technical operation) of urban drainage as a complete process for the disposal of controlled waste and storm water circulating through the city of Barcelona. All the built and planned retention tanks of CLABSA have a programmable automatic cleaning system, which is capable of dragging the sludge deposited on the bottom by a water wave. Each one has an inlet and an outlet collector that connect to the primary axes of the sewer system and a remote control system which permits the supervision of the operating status and real-time control of the gates. On the other hand, the operation of the tanks is fully controlled by a centralized system for remote supervision and control from CLABSA, which allows an integrated and coordinated regulation of all facilities (gates, pumping stations, retention tanks and treatment plants) (fig.34).

http://www.clabsa.es

ng detail on the deposit's
Miró. Source: Author (2010).

Most of the tanks received 80% of the total investment spent in their construction through European funds (fig.35). As Barcelona's mayor, Jordi Hereu, says "Barcelona is the highest-ranking European city when it comes to putting investment in deposits" (Doncel, 2010).

In fact, Barcelona is already the first European city with the necessary available volume of rainwater tanks to protect beaches and rivers and one of the best prepared when it comes to fighting against floods. As the Deputy Mayor for Environment, Imma Mayol, stated "these deposits will help us to avoid having to dump some 900 tonnes of toxic waste into the sea every year" (Doncel, 2010).

[10] Detailed information on their location and design configurations can be seen in annex III.

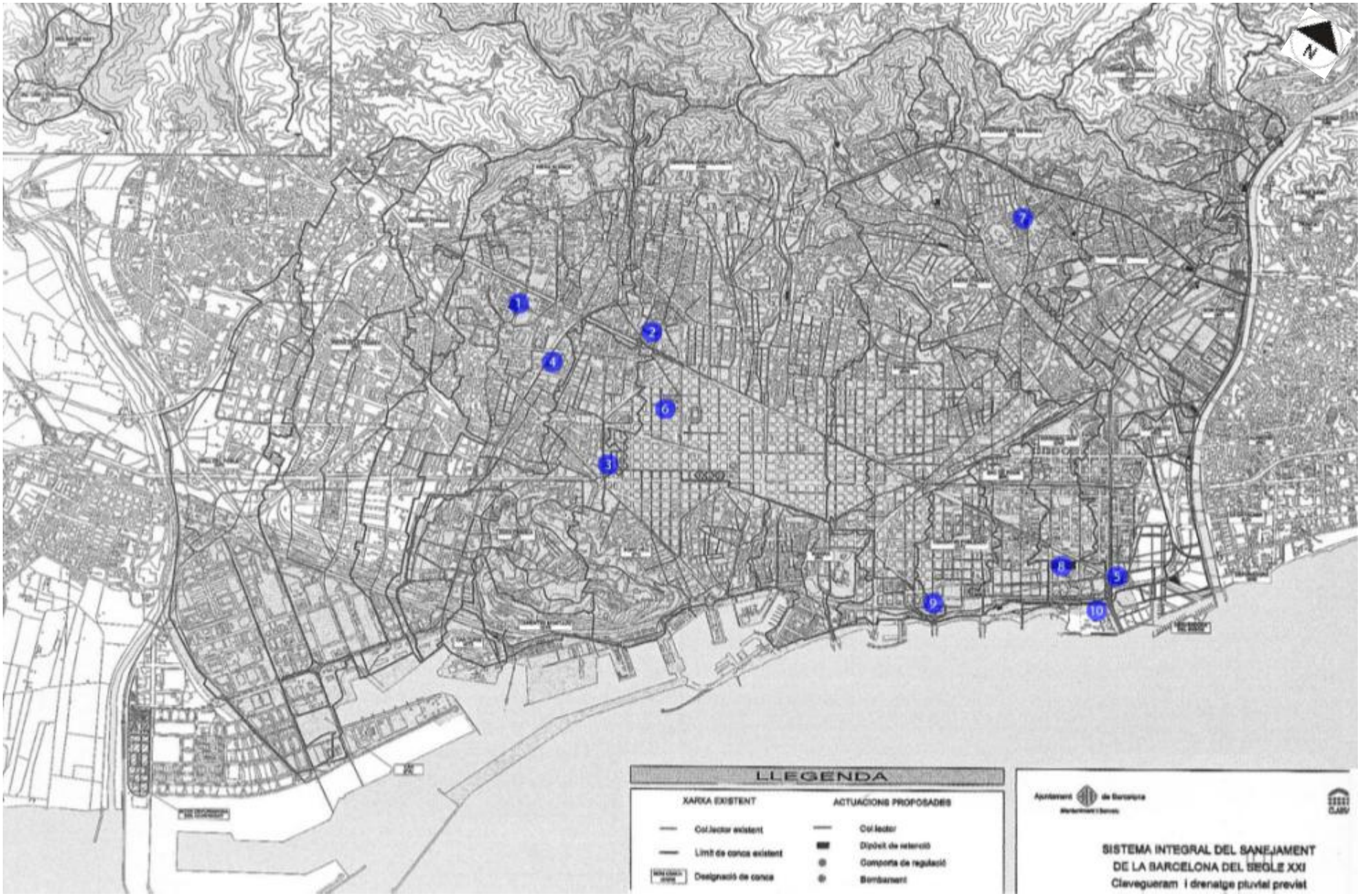


Fig. 36 - Location of the existing tanks over the "Plan Especial de Alcantarillado de Barcelona" (PECLAB). As can be noticed, some of the planned tanks aren't built yet. Source: Adapted from ACA (2009).

There are plenty of different tank types, but basically they can be divided into: 1) retention basins in open sky, where there is space available for their deployment, and 2) underground deposits.

At the present time, Barcelona has 11 rainwater-retention tanks in operation, all located in the urban area with a total capacity of approximately 415 000 cubic meters (Table 3 and fig.36). As mentioned before, these huge tanks allow a reduction of the outflow into the sea of hundreds of tones of solid material suspended in the water every year, by means of the regulation of millions cubic meters of water. Their role in urban flood control is also relevant for optimizing the operation at full capacity of the main drainage axes during intense rainfall, avoiding several floods in the city and making Barcelona's Mayor, Jordi Hereu, confident enough to announce that "Barcelona is prepared for all rain storms" (Doncel, 2010).

Table 3 - Deposit's identification and summary of main characteristics. Source: Author's compilation (2010).

ID	NAME	DEPOSIT TYPE	PUBLIC SPACE TYPE	WATER VOLUME (m3)	EXECUTION	ACTIVATED AT
1	**Zona Universitària**	Underground	Parking lot	105.500	23 months	Feb'00
2	**Bori i Fontestà**	Underground	Garden and Street	71.000	23 months	Feb'00
3	**Parc Joan Miró**	Underground	Park	55.000	26 months	Set'03
4	**Doctors Dolsa**	Underground	Plaza	50.500	24 months	Feb'03
5	**Taulat**	Underground	Street	57.000	25 months	Mar'04
6	**Escola Industrial**	Underground	Sports field	27.000	15 months	Feb'99
7	**Parc Central Nou Barris**	Underground	Park	14.000	19 months	Mar'03
8	**Diagonal Mar**	Open sky	Lake	17.500	-	Feb'03
9	**Parc del Poblenou**	Open sky	Lake	1.400	-	Feb'92
10	**Plaça Fòrum**	Underground	NOT a public space	800.000	-	Mar'04
11	**Mallorca - Urgell**	Underground	Street	16.000	23 months	Out'10
			TOTAL	**415.700**	**522.400 + x**	

A specific research focused on each deposit led to a precise identification of their location and configuration design, allowing, at the same time, a correct photographic survey on what kind of public space exists in the correspondent surfaces – this detailed information can be seen in annex III.

Due to their location in an urban area, and to Barcelona's tradition of public space quality (cf. chapter "Public Space in Barcelona"), most of the tanks, underground or in open sky, deposits or retention basins, include different kinds of public spaces: parking lot, plaza, street, garden, park, sports field, lake. The only exception is the deposit of "Plaça Fòrum" whose surface cannot be considered as public space, not only because it's very small but especially because it is located inside a private facility.

When analyzing these public spaces, one of the first identified aspects was the common existence of mandatory structures (that exist to supply a certain function) that are responsible for the best operation of the tank's infrastructure. As long as these structures must be included, design creativity will be directly allied with the relations between functional and beautiful.

Although the possible symbiosis relation between infrastructure and public space might be obvious for a city like Barcelona, for any other Mediterranean city it's not so. And by having in mind the possibility of exporting this kind of thinking, regarding these deposits, for instance to Lisbon, a thoughtful systematization of such requisites is imperative. Simultaneously, and as a consequence of understanding the need for such structures, new design opportunities can be thought of.

It was also interesting to notice the particularities of two kinds of civil construction techniques used to build the underground deposits. They served as a reference that there is no need to stop a city in order to construct this required infrastructure.

Concrete examples will now help to develop what has just been written:

Common characteristics

As thought throughout the Master "Disseny urbà: art, ciutat, societat", Public Space is much more than the sum of its physical parts, it also consists in spaces that allow social significance to the citizens that use it, according to Antoni Remesar, they are "fundamental per al desenvolupament de polítiques socials i ciutadanes" (A. Remesar *in* (Ulldemolins, 2009). On the other hand, a good public space design should also include some fundamental characteristics in order to be appreciated by all kinds of citizens: a space that promotes human contact and social activities; that is safe, welcoming, and accommodating for all users; that has design and architectural features that are visually interesting; that promotes community involvement; that reflects the local culture or history; that relates well to bordering uses; that is well maintained, that has a unique or special character; etc.

Fig. 37 – Vertical ventilation shaft at *Mallorca – Urgell*. Source: Author (2010).

Besides the immaterial and material elements inherent to these characteristics, the designer of the particular spaces that contain tanks must also consider the mandatory elements responsible for the infrastructure's proper functioning, not only because they are vital but also because they interfere with the design options. Underground deposits or open sky retention basins have different requisites and it's up to the designer to choose whether to use them in a discreet or manifest way.

Fig. 38 – Leveled ventilation shaft at *Doctor Dolsa*. Source: Author (2010).

For what is visibly noticed, the retention basins essentially need a machinery room with pedestrian access and watergates. Underground deposits must also have a ventilating system and expansion joints whenever considered necessary. Considering these last, not only the plantation might be limited to certain parameters, but also the implementation of hydrants could be necessary.

Fig. 39 – Standard pedestrian access to the machinery room at *Doctor Dolsa*. Source: Author (2010).

The ventilation system, only compulsory in the underground deposits, can use vertical shafts or ground leveled grids. The vertical ventilators are usually big in volume and presence, comparing to the ground leveled (fig.37 *vs* 38). A combined solution can be used, minimizing the number of vertical ventilators or the areas of the leveled ones.

Because of the surface area of the vertical ventilators, they are propitious to the display of any kind of message (advertising posters, graffiti, etc). On the other hand, they are usually strong and unbreakable structures that don't seem to have significant functional problems. As for the ground leveled grids, once they present a much higher probability of obstruction (leafs, garbage, etc), their proper functioning is not so guaranteed.

Fig. 40 – CESPA truck using *Parc Joan Miró's* tank entrance. Source: Author (2010).

The pedestrian access to the machinery room is compulsory for both tank types and its design can vary from a standard construction (fig.39) to a specific design solution. Also, the extraction of water with the help of flexible pipes can be made through watergates but it can also be compatible with the pedestrian access (fig.40).

Fig. 41 - Expansion joint at Carrer de Bori i Fontestà. Source: Author (2010).

Expansion joints will exist whenever considered necessary by the civil engineers that calculate the underground deposits or any other element built above the deposits (like concrete streets for instance. Fig.41). This kind of infrastructure can be particularity relevant to the design and therefore it should be of interest.

ıt *Doctor Dolsa*'s

ntestà's deposit

ris' central park.

Source: Author

initially planted
labsa es

nowadays, with

Any tree needs the minimum of 1 cubic meter of soil to develop roots, a bush needs at least a depth of 0.5 meters and all kinds of grass need a depth of 0.3 meters. Considering the *Arecaceae* or *Palmae* from the palm family, which botanically are not considered trees, the desirable volume of soil is only of 0.6 m3 once they have a particular small root system.

According to these basic landscape rules, the plantation above the underground deposits is naturally limited. But, as designers know, "limitation" is not "impossibility" and in fact there are innumerous options that can bypass this situation, both design and engineering options. So, as expected, an integrated design approach between engineers and architects[11] is essential. For instance, the concrete top slab can be calculated according to a lot of different variables (costs, load capacity, etc.) and the decision of which variables are most important should be discussed and balanced with all of whom that will intervene in the final result.

Doctor Dolsa's deposit surface has one area with a palm tree alignment and another area with some tree plantations, which makes one wonder whether there was a compromise, between the architects and engineers, regarding the depth of the strip from the deposit to the city level and regarding the slab's load capacity for the needed soil (fig.42). Also, in the case of Bori i Fontestà's deposit, the garden area, with some tree plantations, is approximately 1.8 meters[12] above the street area (both part of the deposit's surface - cf. annex III) (fig.43), and in the Deposit of the Nou Barris central park, a terrain modeling that permitted tree plantations can also be easily noticed (fig.44). So basically one can assume that different areas of the deposit's upper slab, most certainly, have different structural characteristics.

In the public space above the deposit at Joan Miró's park, another design solution was used. A soil bed was raised from the ground city level with some little height differences in its cutouts, from 0.3 to 0.8 meters (fig.45), forming land ramps with a slight inclination. Although it seems that this public park area has been planned so that there could be bush plantations due to the available depth of soil, nowadays only different kinds of grass can be seen.

Another option, seen in the underground deposits inventory, is the *no use* of vegetation, like the *Mallorca Urgell*'s deposit, or the use of artificial vegetation.

[11] "Architects" in a wide sense.

[12] The garden area is 10 steps above the street which corresponds approximately to 1.8 meters.

Nowadays, the sports field over the Escola Industrial's deposit uses rubber grass, although it wasn't the original option as can be noticed in the figures 46 and 47.

Regarding the two open sky retention basins, the plantation of aquatic plants wasn't identified in either, probably due to the water's flow variation and/or because of possible drain's obstruction with branches or other kind of vegetable waste. An option that bypasses this situation is presented at Poublenou's tank were vegetation beds was designed (fig.48).

Finalizing the identified common characteristics of the tanks, whenever possible or adequate, both types can have Hydrants (fig.49).

rrounded by water during)olsa's deposit and its detail.
rce: Author (2010).

Design opportunities

The public space design solutions presented in this report's survey represent a small example of the innumerous options that exist, even considering the imposed restrictions by this kind of studied infrastructure. In Barcelona, more of these deposits will be built[13] and probably also more public spaces, to them associated, will be designed. One can even say that design opportunities are unlimited.

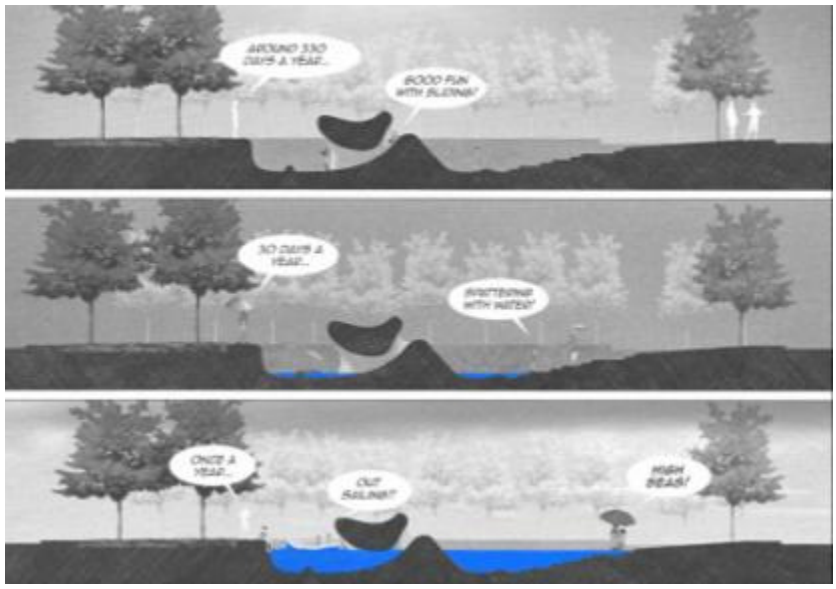
It was inevitable that some possible and adequate design ideas came to mind throughout the systematization of these tank's characteristics. For instance, inspired by an element at Joan Miró's deposit (fig.50), the use of water excess, in the rainy season, for recreational proposes like waterfalls or fountains (fig.51). Or even, in design solutions with gardens, questioning the engineers whether it would be possible to separate the rain water, collected from the intrinsic space and/or its close surroundings, for irrigation of those particular green areas.

In exterior retention basins, for instance, the design can go from a simple shape to a complex one (examples of Poubenou's and Diagonal Mar's tank, respectively). Inspired by Poublenou's tank, where the water flow is very significant, the space design can even be thought for a different use during winter or summer, respectively with or without water (fig.52). In fact, as can be seen in the comic book "De Urbanisten and the wondrous water square" (Boer, Jorritsma and Peijpe, 2010), ideas to capture water in the city in a visible way are almost unlimited: floating squares with rigid or flexible floor, water bags and sponge sculptures are just a glimpse of many possible design solutions (fig. 53).

Nevertheless, the biggest opportunity of all is the possibility to see this enormous infrastructure not as an isolated and untouchable urban element but as a possible integrated constituent of a public space. By interconnecting planning stages, both of engineering and urban design, improved design solutions can arise. And by promoting the existence of more quality public spaces, urban continuity will also be improved. According to Antoni Remesar and Pedro Brandão, Public Space is a structural element of the urban form organization once it allows the balanced functioning of the system, "… pode organizar um território capaz de suportar diversos usos e funções (…), ser um espaço da continuidade e da

[13] At least 30 more, as mentioned *in http://www.clabsa.es/ESP/DipositsBCN_DEPP.asp*

diferenciação, ordenador do bairro, articulador da cidade, estruturador da região urbana …" (Brandão and Remesar, 2000). It presents an integrative role in the territorial and functional continuity of the city as much as it is an important factor in the city's identity, meaning that its existence in "quality" must be preserved and encouraged.



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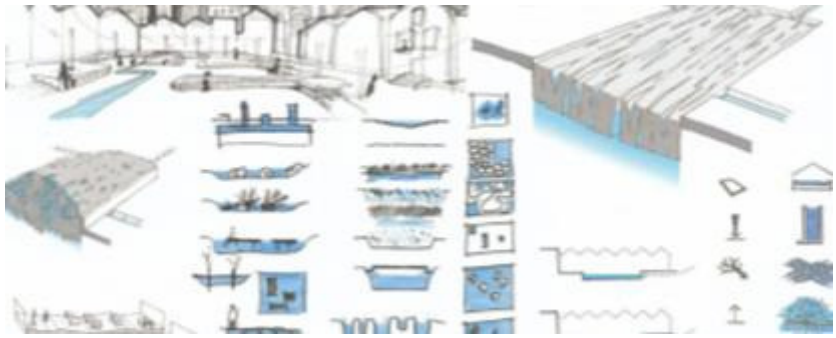

e the excess of rain water in a

Civil construction particularity

Another interesting thing about these deposits is the way some of them were built. As can be seen in table 3, it takes an average of 23 months to raise this kind of infrastructures, an amount of time that can compromise a city's well functioning.

Considering this, when the deposit's construction didn't interfere with the city's day-to-day, because it was located in a private/restricted area or because it was in non-consolidated urban area or park (the cases of *Escola Industrial* and *Plaça Fòrum*'s deposits and *Zona Universitària* and *Parc Central Nou Barris'* deposits, respectively), the infrastructure's construction followed a common method, starting primarily with an excavation until it's foundations and then raising the infrastructure form bottom to top. In contrast, when the deposit's construction could restrain certain city areas from their natural flow, the infrastructure's construction followed the so called "Milan Metro" process (Carreras et al., 2009), a method which consists on a constructive descending procedure that was first used in the Milan subway (the cases of the deposits in streets: *Bori i Fontestà*, *Taulat*, *Mallorca – Urgell*; and the cases of deposits in urban consolidated areas: *Parc Joan Miró* and *Doctors Dolsa*).

In this last case, the construction starts with the implementation of the exterior walls using screens, followed by the execution of the top slab and drilled columns. After the structure is consolidated, the digging of the deposit's interior can start. By using this method, the traffic (for example) can return to its

flow just after the top slab is finalized, even with the excavation and underground works still in process (fig.54).

These different methods, used in the deposits' construction, are clearly perceived in the interior pictures systematized in annex III, once the columns surfaces are very distinct, varying according to the used technique (fig.55 – "Milan Metro" method, fig.56 – "bottom up" standard method).

: Fig. 54 - Bori i Fontestà's deposit. Source: (CLABSA, 2010).

ɔna Universitària's deposit. ɨSA, 2010).

REMAINING QUESTIONS

Barcelona will continue to invest fortunes in this retention tanks. There are 30 more planned tanks[14] with a total capacity over 1.100.000m3. Thinking about the economic weight if this investment it is natural to wonder if it is a good one. Why not invest on separating part or all of the combined systems into distinct storm and sanitary sewer systems? Maybe this could even imply that the water of the storm sewer could be used to irrigate the public gardens! Nevertheless, in an article by L. Mehl, although it is said that this operation is feasible it also states that "an evaluation of the most appropriate CSO control should be performed prior to selecting sewer separation or any other measure" (Mehl, 1999), meaning that there are a lot of negative impacts associated with sewer separation that should be taken into account and so that this option is not necessarily the best one.

On the other hand, P. Williams, on the topic of redesigning the water engineering facilities, refers that large-scale investment in hydraulic engineering infrastructures may become obsolete with changing climate, requiring redesign and reconstruction. He also adds that the first requisite for policymakers to respond effectively to climate change is to understand the challenge as a resource management question, not as a hydraulics engineering or plumbing problem (Williams, 1989). Essentially, an efficient and sustainable use of water resources requires the resolution of many competing goals and approaching this question with a broader perspective will require a major rethinking of not only the existing policies but also the existing urban design solutions. For all these reasons, learning to live with water may be the key concept in the search for new solutions, as far as public space is concerned.

Even so, there is no doubt that Barcelona always seized the opportunities to improve the water drainage system in every major urban renewal. Also, this backstage phenomenon, rarely mentioned as an urban element liable to exportation, permits a part of Barcelona's city functioning as we know it. On the other hand, it is so intrinsically urban that it may go unnoticed. Adding Climate Change, the opportunities that come alongside with this intelligent system, that aims to make Barcelona one of the great "flooding proof" *urbes*, are probably innumerous and should be furthered researched.

[14] New planned tanks: Hospital Militar, Navas, Carmel - Clota - Vall Hebron, Parc de la Guineueta – Artesania, Sagrera – Prim, Can Batlló, Gran Via l'Hospitalet (en construcción), Guipúscua Alarcón, Torrent Estadella / Bon Pastor, Interceptor Estadella, Interceptor de Rieres, Torre Baró / Torrent Tapioles, Vallbona, Bac de Roda, Bogatell, Ciutadella – Barceloneta, Port Vell 1, Port Vell 2, Can Tunis, Zona Franca – Motors, Amadeu Torner, Seat, Carrer 4, Carrer 6, Ciutat judicial, Les Planes, Can Boixeres, Bassa IZF, Ikea L'Hospitalet (en construcción), Dipòsit del Camp de l'Empedrat (pendiente puesta en marcha).

5. CONCLUDING CONSIDERATIONS

This report started with an historical overview on Barcelona's evolution as a city, giving a special emphasis on the distinctiveness of "Modelo Barcelona" and its public space, so highly regarded in the scientific community. It was evidenced that the concern about rain runoff and flood prevention came since Cerdà's "Ensanche" plan, a specific subject of the plan's components which was further studied and implemented by Garcia i Faria in 1981.

Regarding "Modelo Barcelona", in the deepening of the concept's meaning and historical evolution, it was perceived the real necessity of interrelation between the social practices and the *form* of public space, as well as the importance given to urban design once it is a subject that qualifies the hole urban collectiveness, both materially wise (physical occupation and urbanism wise) and immaterially wise (historically, culturally, socially, identity wise), and that consequently conditions urban life. As it is clear throughout the text, the importance and dignity of public space was in the basis of the so called "modelo" and also of its success. Supported by Bohigas idea to "rehabilitate the center and monumentalize the periphery", Barcelona found a new way to build a city.

Nowadays the "model" suffers from strong criticism, from the heightened importance of tourism to the public/private intervention policies and obedience to global markets, both undermining needs and desires of the local population. Nevertheless, other kinds of investment are being made, maybe not so visible but as important to society as the ones made in the eighties. The case of flood prevention strategies and infrastructure, is just an example. There are also other kinds of "backstage" infrastructures that contribute every day to the citizens quality of life (metro network and the innovative solid waste pneumatic collection system[15], for instance).

Even so, it can now be recognized, through the report's work, that, despite its faults, "modelo Barcelona" contributed to a better articulation between public space and the necessary infrastructure invested for the city and its citizens.

The occurrence of flash floods is a very common feature in Catalunya and particularly in Barcelona. In past years, open and exposed water courses, coming from a steep slope and with a non-permanent flow, traverse Barcelona's plain in parallel, perpendicular to the sea. When heavy rains or a long rainy period arose over or near the city, their overflow produced significant damage. Most of these water courses are nowadays channeled underground and interconnected to pipes that belong to Barcelona's drainage system. This network has improved in recent years with the construction of underground storm tanks. As a consequence, heavy rainfall effects over the city are not the same as in the past.

However, even in the present days, Barcelona has inherent characteristics that make the evacuation of rainwater particularly complex. On one hand, impermeable land area generates large volumes of runoff due to the reduced absorption of the ground. On the other hand, the topography of the city includes the upper Collserola, a steep slope that doesn't allow infiltration, which softens up only in the bottom plain. Naturally, this topography leads to a rapid concentration of rainwater in the lower lands, continuing its flow in a slow velocity until reaching the sea.

As explained previously, Barcelona's annual rainfall is approximately 580 mm on average, i.e. 580 l/m2, but with isolated episodes of high intensity rainfall. It was also evidenced that, although the number of catastrophic flash floods has diminished, the extraordinary ones have increased[16]. Adding to these facts the facts of climate change, one can't help but take them into consideration. The possible impacts caused by climate change are so catastrophic that any existent scientific uncertainty cannot be a reason to delay public and political awareness to the need of adaptation.

As studied in the chapter "Media and social impact", researches report that climate change is unequivocally a reality in today's society. In this chapter, they also comment about the positive trend of

[15] To know more cf. *CASTELLTORT, R.M.F. Pneumatic Refuse Collection. geographyfieldwork.com - Barcelona Field Studies Centre, 2009.*

[16] To better understand the concepts "catastrophic" and "extraordinary" see chapter "Chronology of flash-floods".

media news regarding this subject, which can be related to several reasons: whether because there is a decrease of the tolerance thresholds of the people involved, now considering as extraordinary some situations that were once accepted as ordinary; or because there is an increasing amount of available information on all areas related to environment and natural hazards; or increased losses associated with both an increase in population in areas of flood risk and to the value of the materials exposed; or even related to an increase of social mobility that leads to an ignorance of the environment and exacerbates the reckless actions. But, for whatever reason, there is no doubt that the media has a decisive influence on the views of the population. Regarding climate change, one could say it is a *good* influence because not only it raises social awareness but also it forces answers from the government.

Due to all its intrinsic characteristics, since early Middle Ages, Barcelona has prepared itself against the damaging impacts of floods, from Garcia i Faria's "Plan de Saneamiento de Barcelona" of 1891, to the contemporary "Plan Especial de Alcantarillado de Barcelona" (PECLAB) of 1997. Some say that, because of the long-term vision of the future applied in studies, rigorous works and important decision-making, Barcelona is nowadays one of the most prepared cities in urban drainage wise.

The highlight of PECLAB's proposed actions was the implementation of regulation tanks that not only allow further water depuration by reducing of the outflow into the sea of hundreds of tones of solid material suspended in the water every year, but also avoid large accumulations of water in certain areas when major floods occur, retaining storm-rain-water long enough to subsequently evacuate it little by little. Because of these huge tanks, designed and constructed by CLABSA, Barcelona's Municipality is now confident enough to advertise that Barcelona is prepared for any rain storm. Even so, one must point out that, as mentioned before, there is a high degree of uncertainty concerning the magnitude and direction of the climate change effects on the hydrologic cycle, therefore large-scale investment in hydraulic engineering infrastructures may become obsolete with changing climate, requiring redesign and reconstruction.

It is a fact that Barcelona is the first European city with the necessary available volume of rainwater tanks to protect beaches and rivers and one of the best prepared when it comes to the fight against floods. Currently these, so far eleven, rainwater-retention tanks, all located in the urban area, have a total capacity of approximately 415 000 cubic meters. But what in this report is considered to be interesting is not their capacity or construction volume but their visible existing relationship towards public space.

Barcelona's public spaces related to these tanks go from open sky retention basins to underground deposits. While in the first type they are a constituent part of the surrounding public space, for example as a lake that can have water flow variability, in the second type, many kinds of public space can exist in their surface: plazas, sports fields, parking lots, parks, gardens, etc.

The systematization and analysis of these public spaces developed for this report, describes innumerous good examples that can and should be exported to cities were "infrastructure" is seen as an isolated and untouchable urban element.

Theoretically, this report promotes the need to a change of paradigm: infrastructures shouldn't only aspire to serve the objective they were built to accomplish. The point is not that infrastructure should be integrated in urban planning as this basic and fundamental approach is already incorporated in today's knowhow, but to interconnect all planning stages, of both needed infrastructure and urban planning and/or of engineering and urban design, in a transversal and integrated approach that allows to take advantage of all possible opportunities.

Analyzing both developed chapters, "Public space in Barcelona" and "Barcelona's flood reality", one could argue that the city's intrinsic characteristics, its history, culture, society, climatic and morphologic uniqueness, etc, were very decisive, if not the "key", to the success of the mentioned correlation between needed infrastructure and public space. It's no coincidence that other cities, that are "about to" or have already invested in similar tanks, didn't take advantage of its possible multi-function capacity to encourage more quality in public spaces. Lisbon, for instance, is one good example as the PGDL ("Plano

Geral de Drenagem de Lisboa") proposes the "innovative" construction of several retention tanks (fig.57) and only occasionally mentions the possibility of other parallel functions (Oliveira et al., 2008).

Indeed, in this report's particular case study, the advantages of the mentioned relationship "infrastructure"/"public space" are clear. They are a particularly noteworthy case since they represent on a good practical example, likely to be explored and exported to cities with similar characteristics and necessities. Could it even be considered as another component of "Barcelona's model" that cities could choose to follow?

The Alcântara valley in Lisbon, for instance, has a high tendency to big magnitude floods where runoff waters from the big side slopes converge. Considering the climate change scenarios, as it is also considered a Mediterranean city, extreme events are presumed to become more frequent and intense. It is also a place with significant urban pressures where several infrastructures can be found and where successive planning strategies always introduce the implementation of new infrastructures that are big both in size and investment.

The recent Alcântara PU ("Plano de Urbanização"), of July 2010, proposes the implementation of a number of infiltration basins throughout the valley. These spots are planned to be green public areas, like a linear park where in some determined spots water is accumulated in a controlled way. Nevertheless, the plan also envisages the construction of two retention underground deposits: one near the "Bairro da Liberdade" and another in "Campolide", with the capacity of 38100 m3 and 13400 m3 respectively (fig.58) (CML, 2010). Although it is once referenced in this document that the deposit near the "Bairro da Liberdade" has the possibility to have a garden on its surface - "…a superfície do terreno poderá vir a ser ocupada por uma zona ajardinada"("sistema de drenagem hidrica" in (CML, 2010)) - it is clear that the exterior urban areas, that include or that surround these infrastructures, are no main concern.

Consequently, this report could help to improve these known strategies by introducing the knowhow of the previously explained qualities of Barcelona's correspondent examples. Adding public space design to rain-water drainage infrastructures is not only feasible but a win-win situation. In Alcântara's particular case, this sea of relationship opportunities can still be further researched, and considering today's economic crisis, today's certainties regarding climate change and today's experience regarding obsolete and expensive drainage engineering, it is most certainly important to do so.

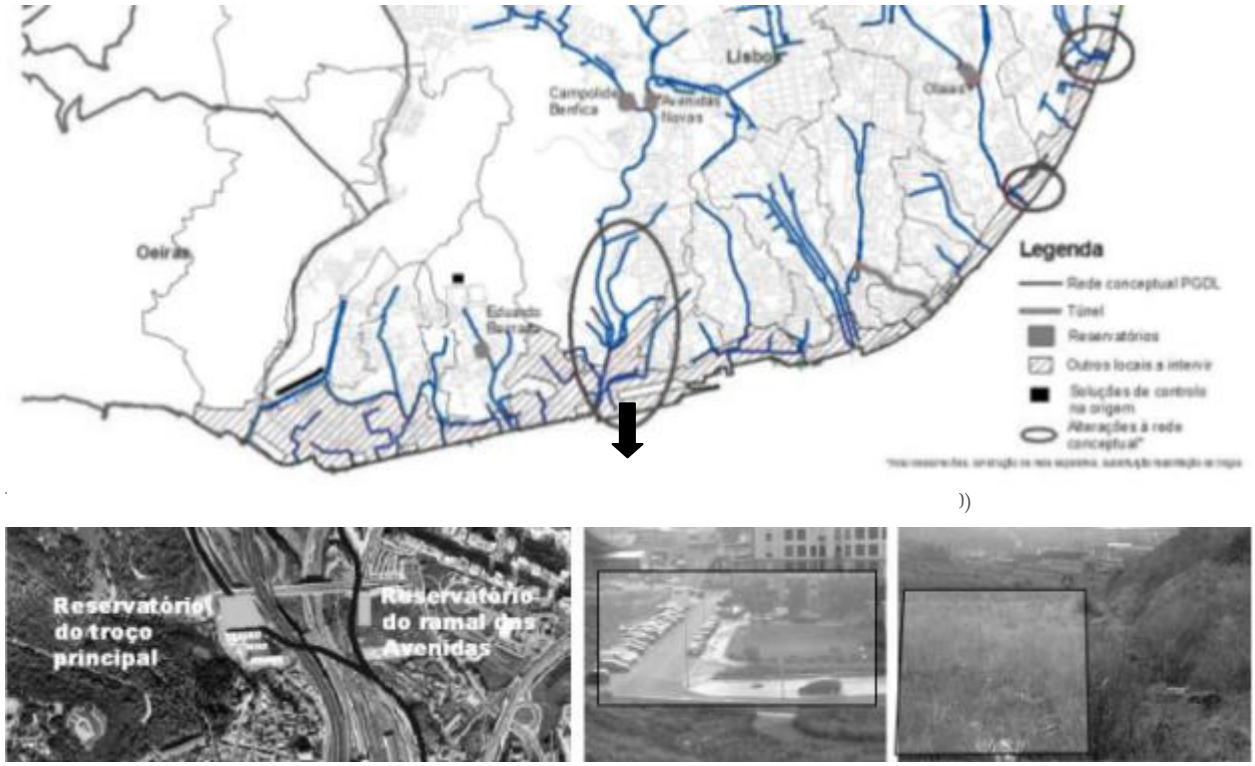

Fig. 58 – Proposed interventions on the PGDL. On the right - the Benfica-Campolide reservoir; on the left - the Av. Novas reservoir. Source: Adapted from (Oliveira, Matos, Monteiro, Ferreira, Marques and Simões, 2008)

6. BIBLIOGRAPHY

AA.VV. *Guia de Barcelona*. edited by M.Á. SÁNCHEZ. Edtion ed. Madrid: El Pais - Aguilar, 1991. 271 p.

AA.VV. *Barcelona. Un modelo de transformación urbana.* edited by J. BORJA. Edtion ed. Quito: Ajuntament de Barcelona- PGU, 1995.

ACA, A.C.D.L.À. Aigua i canvi climàtic - Diagnosi dels impactes previstos a Catalunya. In D.D.M.A.I. HABITATGE. *Escenaris Climàtic.* Generalitat de Catalunya, 2009.

ACA, A.C.D.L.À. Pla d'emergència especial per inundacions (INUNCAT). In.: Civil Protection Department of the Generalitat de Catalunya (DGPC), 2010, p. 130pp.

ALEMANY, J. *El Port de Barcelona*. Edtion ed. Barcelona: Port de Barceloma, 1998. 315 p.

ARTEHISTORIA. El Paseo de Gracia (Barcelona). vol. 2010, no. April. Available from Internet:<http://www.artehistoria.jcyl.es/histesp/contextos/6170.htm>.

BALIBREA, M.P. Memória e espaço público na Barcelona pós-industrial. In *Revista Críitica de Ciências Sociais*. Lisboa, 2003, p. 31-54.

BARRERA, A., BARRIENDOS, M. AND LLASAT, M.C. Extreme flash floods in Barcelona County. Advances in Geosciences, 2005, vol. 2, p. 1-6.

BARRIENDOS, M., BARRERA, A. AND LLASAT, M.C. Estimation of extreme flash flood evolution in Barcelona County from 1351 to 2005. Natural Hazards and Earth System Sciences, 2006, p. 505-518.

BATES, B., KUNDZEWICZ, Z.W., WU, S. AND PALUTIKOF, J. *Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change*. edited by I. SECRETARIAT. Edtion ed. Geneva, 2008. 210 p.

BLADÉ, I., CACHO, I., CASTRO-DÍEZ, Y., GOMIS, D., GONZÁLEZ-SAMPÉRIZ, P., MIGUEZ-MACHO, G., FIZ, P., RODRÍGUEZ-FONSECA, B., RODRÍGUEZ-PUEBLA, C., SÁNCHEZ, E., MARCOS, G.S., VALERO-GARCÉS, B. AND VARGAS-YÁÑEZ, M. Clima en España: Pasado, presente y futuro - Informe de evaluación del cambio climático regional [online]. Fiz F. Pérez y Roberta Boscolo; Mº de Medio Ambiente y Medio Rural y Marino, Mº de Ciencia e Innovación, 2010.

BLANQUET, M.Á.C. La Barcelona que no se ve. *las redes de servicios y energías* [Type of Work]. 2004. Available from Internet:<http://www.bcn.es/urbanisme/model/expo/castella/pg4clavero.htm>.

BOER, F., JORRITSMA, J. AND PEIJPE, D.V. *De Urbanisten and the wondrous water square*. Edtion ed. Rotterdam: 010 Publishers, 2010. 46 p.

BOHIGAS, O. *Reconstrucción de Barcelona.* Edtion ed. Madrid: Edicions 62, 1986.

BOTIJA, M., LLASAT, M.C. AND LÓPEZ, L. Natural Hazards and the press in the western Mediterranean region. Advances in Geosciences, 2007, p. 81-85.

BRANDÃO, P. AND REMESAR, A. *O Espaço Público e a Interdisciplinaridade* edited by CPD. Edtion ed. Lisboa, 2000.

BURIAN, S.J., NIX, S.J., DURRANS, R., PITT, R.E., FAN, C.-Y. AND FIELD, R. The historical development of wet-weather flow management. EPA, 1999, vol. US Environmental Protection Agency, p. 23.

BUSQUETS, J. *Barcelona: La construción urbanística de una ciudad compacta*. Edtion ed. Barcelona: Ediciones del Serbal, 2004.

CALAVITA, N. AND FERRER, A. Behind Barcelona's Success Story. Journal of Urban History, 2000, vol. Vol. 26, no. No. 6, p. 793-807.

CANTOS, J.O. Prevención de riesgos: cambio climático, sequías e inundaciones. In C.U.D.S.-M.D.M. AMBIENTE. Sevilha: Fundación Nueva Cultura del Agua, 2009.

CAPEL, H. *El Modelo Barcelona: Un Examen Crítico*. Edtion ed. Barcelona: Ediciones del Serbal, 2005.

CAPEL, H. De nuevo el modelo Barcelona y el debate sobre el urbanismo Barcelonés. Revista bibliográfica de Geografia y Ciências Sociales, 25 de enero 2006, vol. Vol. XI, no. nº 629, p. 16.

CAPELL, M.D.T.I. *La Formació de la Urbanística Metropolitana de Barcelona. L'Urbanisme de la Diversitat*. Edtion ed. Barcelona, 1999.

CARDOSO, J.D.J. Património Ambiental Urbano & Requalificação. Contratações do Núcleo Histórico de Santos. In *Departamento de Geografia.* São Paulo: Universidade de São Paulo, 2007, vol. Doutoramento, p. 321.

CARRERAS, M.B., TEIS, Ò.P. AND BUNDÓ, M.S. Procediments de construcció - Dipòsit de regulació pluvial d'Urgell- Mallorca i col·lectors associats. In. Barcelona: CLABSA, 2009.

CASANOVAS, M.M.I. Cap a una cultura urbana de l'espai públic: l'experiència de Barcelona (1979-2003). In *Departament d'Urbanisme i Ordenació del Territori.* Barcelona: Universitat Politècnica de Catalunya, 2004, vol. Tesi doctoral, p. 508.

CASTELLTORT, R.M.F. Pneumatic Refuse Collection. geographyfieldwork.com - Barcelona Field Studies Centre, 2009.

CERDÀ, I. Teoría General de la Urbanización de sus Principios y Doctinas a la Reforma y Ensanche de Barcelona. In.: Archivo Cerdà (http://www.anycerda.org), 1867.

CID, S.T. Un continuador de la obra de Cerdà: Pere Garcia Faria Cuadernos de arquitectura y urbanismo, 1974, vol. 100 no. Cerdà : un pasado como futuro, p. 45-49.

CML. Plano de Urbanização de Alcântara. In. Lisboa: Departamento de Planeamento Urbano; Direcção Municipal de Planeamento Urbano, 2010.

CODRÓN, G. AND CERVERA, S. Riesgos Naturales en los Andes: Cambio Ambiental. Boletín de la A.G.E, 2000, vol. núm. 30, no. Percepción y Sostenibilidad, p. p. 69-84.

COROMINAS, M. AND BUSQUETS, J. *Cerdà i la Barceloma del Futur*. edited by CCCB. Edtion ed. Barcelona: Diputació de Barcelona, 2009.

CUNHA, L.V.D., OLIVEIRA, R. AND NUNES, V.B. Impactos das Alterações Climáticas sobre os Recursos Hidricos de Portugal 2008.

DELGADO, M. *Elogi del Vianant: del "Model Barcelona" a la Barcelona Real*. Edtion ed. Barcelona: : Edicions de 1984, 2005.

DONADEU, R.A.I. Evolució del Soroll a Barcelona durant els anys noranta In C.D.M.A.I.S.U. PRESIDÈNCIA. *Medi Ambient i Serveis Urbans* Barcelona: l'Ajuntament de Barcelona, 1996, p. 36pp.

DONCEL, M. Barcelona launches a rainwater deposit with a holding capacity of eight Olympic swimming pools. *News* [Type of Work]. 2010, vol. 2010, no. November. Available from Internet:<http://w3.bcn.es/V01/Serveis/Noticies/V01NoticiesLlistatNoticiesCtl/0,2138,1653_1802_3_1363479560,00.html?bcnAccessible=true&accio=detall&home=HomeBCN>.

ESTEBAN, J. *El Projecte urbanistic: valorar la periferia I recuperar el centre*. edited by A. BARCELONA. Edtion ed. Barcelona, 1999.

EU, J.O.D.U.E. Directiva 2007/60/CE do Parlamento Europeu e do Conselho da União Europeia relativa à avaliação e gestão dos riscos de inundações. In P.E.E.D. CONSELHO. 2007.

FRACASSO, L. Barcelona: Un Modelo en discusión y una realidad sin discutir Revista bibliográfica de Geografia y Ciências Sociales, 5 de septiembre 2006, vol. Vol. XI, no. nº 673, p. 11.

INUNCAT. Pla Especial per Inundacions a Catalunya - En revisió. In C.D.P.C.D. CATALUNYA. 1997.

IPCC. Climate Change 2007: Impacts, Adaptation and Vulnerability. In.: Intergovernmental Panel on Climate Change, 2007.

IPCC. Climate Change 2007: Synthesis Report. 2007. Available from Internet:<http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm>.

LLASAT, M.C. El canvi climàtic i la percepció del risc d'inundacions a Catalunya. In J.D. TÀBARA. *Percepció pública i política del canvi climàtic a Catalunya.* Barcelona: Generalitat de Catalunya Departament de la Vicepresidència Consell Assessor per al Desenvolupament Sostenible de Catalunya (CADS), 2008, p. 59-72.

LLASAT, M.C., LOPEZ, L., BARNOLAS, M. AND LLASAT-BOTIJA, M. Flash-floods in Catalonia: the social perception in a context of changing vulnerability. Advances in Geosciences, 2008, p. 8.

LLASAT, M.C., RIGO, T. AND BARRIENDOS, M. The "Montserrat-2000" flash flood event: A comparison with the floods that have occurred in the northeastern Iberian Peninsula since the 14th century 2003, p. 453-469.

LLASAT, M.C. AND RODRIGUEZ, R. Extreme Rainfall Events in Catalonia. The Case of 12 November 1988. Natural Hazards, 1992, vol. 5, p. 133-151.

LLASAT, M.D.C. El canvi climàtic i la percepció del risc d'inundacions a Catalunya. In J.D. TÀBARA. *Percepció pública i política del canvi climàtic a Catalunya.* Barcelona: Generalitat de Catalunya

Departament de la Vicepresidència

Consell Assessor per al Desenvolupament Sostenible de Catalunya (CADS), 2008, p. 59-72.

MACKAY, D. The recovery of the urban seafront. *MBM arquitectes - NEWS* [Type of Work]. 1999. Available from Internet:<http://www.mbmarquitectes.cat/NEWS/pdf/modelbarcelona.pdf>.

MACKAY, D. *La recuperació del front marítim*. edited by A. BARCELONA. Edtion ed. Barcelona: Aula Barcelona, 2000. 45 p.

MARTÍ, A.M. La configuració del paisatge medieval:el comtat de Barcelona fins el segle XI. In *Departament d'Història Medieval, Paleografia i Diplomàtica.* Barcelona: Universitat de Barcelona, 1997, vol. Doctor, p. 421.

MARTI, J. Estratégias Culturais e Renovação Urbana. In. São Paulo: Associated with the discussion of São Paulo's Municipality " presente e o futuro da cidade", 2006.

MATOS, J.D.S. Aspectos Históricos a Actuais da Evolução da Drenagem de Águas Residuais em Meio Urbano. Engenharia Civil - UM, 2003, no. Número 16, p. 12.

MEHL, L. Combined Sewer Overflow Management Fact Sheet. Sewer Separation. EPA, September 1999, vol. United States Environmental Protection Agency, p. 7.

MONCLÚS, F.-J. El "Modelo Barcelona" ¿Una Fórmula Original? De la "reconstrucion" a los proyectos Urbanos Estratégicos (1979-2004) Perspectivas Urbanas / Urban perspectives, 2003, no. Nº3

MONTANER, J. El Modelo Barcelona. In *El País.* Barcelona, 2007.

MONTANER, J.M. El modelo Barcelona. In *El País.* Barcelona, 2007.

MONTANER, J.M., FREIJO, J.P. AND BARNADA, J. *Barcelona 1979|2004. del desenvolupament a la ciutat de qualitat*. edited by A.D.B.D.D.S.E.J. FERNANDO. Edtion ed. Barcelona, 1999.

NORDREGIO. Climate Change - Emergencies and European Municipalities. In N.C.F.S. DEVELOPMENT. *Guidelines for Adaptation and Response*. Sweden, 2007.

OECC, O.E.D.C.C. Plan Nacional de Adaptación al Cambio Climático. In M.D.M. AMBIENTE. 2006.

OLIVEIRA, R.P.D., MATOS, J.S., MONTEIRO, A., FERREIRA, F., MARQUES, R. AND SIMÕES, J. Modelo hidrológico e hidráulico para avaliação do desempenho de uma rede de drenagem urbana. In C.D. ÁGUA. Lisboa: Chiron, Engidro, Hidra, 2008.

REMESAR, A. Reflexiones sobre la privatización del espacio público. In *intervir.* Câmara Municipal da Moita - Departamento de Planeamento e Gestão Urbanística 2005, p. 4.

RIDRUEJO, S. Ildefonso Cerda y la evolución urbana de Barcelona. In *Revista de Obras Públicas.* Madrid, 1972, p. 385-392.

SANTOS, F.D., FORBES, K. AND MOITA, R. *Climate Change in Portugal Scenarios, Impacts and Adaptation Measures*. Edtion ed. Lisboa: Gradiva - Publicações, L.da 2002. 456 p.

SANTOS, F.D. AND MIRANDA, P. *Alterações Climáticas em Portugal. Cenários, Impactos e Medidas de Adaptação* Edtion ed. Lisboa: Gradiva, 2006.

TÀBARA, J.D. Percepció i comunicació sobre el canvi climàtic. In J.E. LLEBOT. *El canvi climàtic a Catalunya.* Barcelona, 2005, p. 772-815.

TARRAGÓ, F. *Cerdà. Ciudad y Territorio. Una visión de futuro*. edited by M.D. FOMENTO. Edtion ed. Madird: ELECTA, 1996.

TORNER, F.M. La propuesta de saneamiento de Cerdà para Barcelona. Revista del Colegio de Ingenieros de caminos, canales y puertos, 1995, vol. Saniamiento II, no. Nº33, p. 16 pp.

ULLDEMOLINS, N.R. Cartografies de La Mina - Art, Espai Públic, Par ticipació Ciutadana. In *Programa de doctorat Espai Públic i Regeneració Urbana: Art, Teoria i Conservació del Patrimoni.* Barcelona: Universitat de Barcelona, 2009, vol. Doctor.

WILLIAMS, P. Adapting Water-Resources Management to Global Climate Change Climatic Change, Oct 1989, vol. 15, no. 1-2, p. 83-93.

WWW.SPAIN-BARCELONA.COM. Barcelona - History. 2002, no. 10-11-2010. Available from Internet:<http://www.spain-barcelona.com/barcelona/history.htm>.

7. NAME INDEX

8. FIGURES INDEX