CIDADES, Comunidades e Territórios

Lisbon Territory from a morphological and environmental approach: Lessons for a Sustainable Urban Agenda

Teresa Marat-Mendes, Instituto Universitário de Lisboa (ISCTE-IUL), DINÂMIA'CET-IUL e Departamento de Arquitectura e Urbanismo, Lisboa, Portugal[1]

Abstract

This paper introduces the debate of sustainable development from a fresh perspective. Through a comparative analysis provided by a number of case studies within the Lisbon Territory, in Portugal, this paper aims to demonstrate how the impact of subterranean and surface water management has determined specific territorial arrangements, urban morphological parameters and urban design solutions within the territory of Lisbon. It is argued that the acknowledgement of such territorial arrangements should provide important lessons that need to be recuperated by the discipline of urban planning in order to contribute to an effective Sustainable Urban Agenda. The specific goal of this article is to contribute to the building of a methodological framework that informs on how to intervene on the urban periphery, while integrating the city and territory; and also, how to make this integration work effectively for mankind and the environment. The sustainability perception that supports this consideration is built upon a vision that professes a non-pollutant urban system; that should result from the transformation of the current productive system, based on a systematic production of residues, into a new productive relationship with the territory.

Keywords: Lisbon; Territory; Environment; Urban Planning; Water; Morphology.

1. Introduction

The motivation for this paper comes from the awareness that there is a social demand urging for the implementation of a Sustainable Urban Agenda, wherein the rural and suburban areas, with their economic, social and environmental problems, have been increasingly recognized as in need for containment and intervention. The PRODER Programme for the Portuguese Rural Development, Law 48/98, altered by Law 54/07 for Portuguese Land Use Planning and Urbanism, along with a number of research and governmental guidelines that have recognized the destructive influence of city growth on its immediate environs and on the regional and global environment. See, for example, The Brundtland Report (WCED, 1987), The Green Paper on Urban Environment (CEC, 1990), the Indicators for Sustainable Urban Development of the United Nations, the Agenda 21, The Urban Task Force (1999) and Políticas Urbanas (Portas et al., 2003, 2011).

[1] Edifício ISCTE, Av. das Forças Armadas, 1649-026 Lisboa, Portugal. Email: teresa.marat-mendes@iscte.pt.

After decades of planning debate, exclusively focused on the Sustainable City (Jenks et al., 1996; Williams et al., 2000; Jenks & Jones, 2010), the territory analysis produced by Garrabou (2006) underlines that the lack of rural and suburban environment evaluation has rendered impractical a serious understanding of the urban and rural periphery. This situation has contributed to a great lack of valid prescriptive tools that could support planning interventions in these territories, while coping with the social, economic and environmental problems of rural and suburban areas.

Guerra (2010), when calling back for discussion the concept of Sustainable City, also claims the need for more systematic and articulated approaches to better ascertain the functioning of the urban systems and to better inform on how to intervene on the built environment. Moreover, Guerra argues that solutions that inform on how to intervene on the territory should preferably be based on concrete territorial examples, as well as the build-up of a strategic vision that considers the territory as a unity. Furthermore, it is also stressed that the main problem of current planning tools is that they arise from a hierarchical functioning perspective. Nevertheless, Guerra's analysis of the sustainable city seems to focus again on the compact city solution (Guerra, 2010: 83).

In addition, Nunes (2010), on a socio-morphological analysis of Lisbon's metropolitan suburban area, attempts to identify the morphogenesis of the Lisbon Metropolis and seems to return to more substantive information and well sustained intervention in the territory based on territorial cohesion as addressed by Faludi (2010), as well as on the integration of knowledge from different scientific areas that has already been requested also by EU guidelines and many other authors (Whitehand and Morton, 2003, 2006).

This paper introduces the debate of sustainable urban planning by drawing attention to the importance of reading the parameters of the territory, i.e., the ground rules or the urban and territorial morphological arrangements, that, when appropriately allocated, enable change to occur within the urban framework but at the same time contribute to its sustainable development. Moreover, it relates such territorial morphological arrangements to their responsiveness to the environment in an integrating manner, as claimed by Guerra (2010), Faludi (2010) and Whitehand and Morton (2003), while supporting a non-pollutant urban system that works in a close material cycle as argued also by Rogers (1997).

Marat-Mendes and Scoffham (2005) have drawn attention to a method of analysis of urban form that also bears on the notion of sustainability. The reading of the capacity of the physical dimensions of urban forms that have been able to adapt and transcend over time in a sustainable manner constitutes the focal point of their methodology. Furthermore, according to these authors, a sustainable urban form is the one that is able to survive through processes of change, and that at the same time provides an environmental quality that responds to the variety of needs over time. Although the work developed by Marat-Mendes (2002) focuses mainly on a comparative analysis of three historical examples of planned urban development, it also seems to be valid to evaluate the physical dimensions of the rural and suburban territory. Thus, the rural and suburban areas should similarly be regarded as part of the built environment analysis if one wishes to achieve a serious understanding of the urban and rural periphery, and therefore contribute to a unitary analysis of the territory as argued by Guerra (2010) and Faludi (2010).

Furthermore, by challenging the debate of environmental degradation and urban planning into areas where strong urban tensions have been caused by the phenomena of the 'diffuse' and 'sprawl', this paper proposes a fresh insight into the discipline of urban planning at a time when a widespread demand for the renewal of this discipline has already been claimed (Rogers, 1997; Guerra, 2010).

Besides, according to a line of thought that is being defended by several authors such as Laureano (1995), Tello (1999) and Marat-Mendes and Cuchí (2008), natural environment should not be understood as a single support for the allocation of different activities, infrastructures, facilities or buildings, but instead as an intrinsic part of a complex global system. Recognition and identification of the inherent proprieties or the qualities of the natural environment, as part of a more general ecological system, is therefore important. As a consequence, the view of nature as something "external" to the urban environment is now open for revision.

Several authors are also claiming revision of the traditional architecture and landscape practices, such as Ábalos (2008). Indeed, when referring to the death of Robert Smithson in 1973, Ábalos considers this moment to be the time of the first energetic crisis and the birth of a new awakening for the need to articulate other nature policies, and among them other strategies for the construction of the territory.

It is precisely the recognition of the need to review current models of urban form and land use in practice that is argued here as being crucial in order to renew the discipline of urban planning. Moreover, it would support new strategies to intervene in our built environment and to construct a sustainable territory. Such revision, already claimed by Ábalos (2009), should promote new urban models that guarantee the working of a close material cycle's system wherein man, nature and the built environment would work as a unity, as before the first energetic crisis, yet based on contemporary needs.

The emphasis attributed to the identification of the dimensions of urban form layout and the real scale of the ecological impacts in the urban planning process thus appear to be all important and reveal an Urban Agenda that should be recovered. This Agenda embraces recognition of land use planning with great respect for the biophysical environment. The emphasis is therefore on the way that both the natural and the built environment can work in an intrinsic manner, guaranteeing sometimes their overlapping function, if possible, in order to enhance a non-pollutant urban system; that should result from the transformation of the current productive system, based on a systematic production of residues, into a new productive relationship with the territory.
In order to demonstrate how the biophysical environment can respond to the built environment, enhancing an appropriate exploitation of its natural resources while guaranteeing the closing of the material cycles that operate in such a system, this paper will now establish how the impact of subterranean and surface water management determined specific urban morphological parameters of urban design over time and in a sustainable manner. To do this, this paper will focus on the analysis of a Portuguese case study that is situated in the western area of the Lisbon region.

2. Climate, soil and the ecological aspects of the Lisbon Region

Figure 1. Map of Lisbon's harbour, bays and surroundings, including a small road map of Portugal

Source: de Le Cher, Calmet-Beauvoisin (scale 1:52000 [aprox.]), Paris: Lithographie de Delarue. 19--.[2]

[2] Available at http://purl.pt/4007, courtesy of Biblioteca Nacional de Portugal.

The Portuguese case study refers to a specific geographical area that is situated in the western region of Lisbon; bounded to the west by the Atlantic Ocean; to the east by the Alcântara water stream; to the south by the mouth of Tagus River, and; to the north by the Sintra Mountains. Figure 1 exhibits with great detail the topography of the western area of the Lisbon territory that is under analysis here, including its hills and water streams.

Located in the territory of the Metropolitan Area of Lisbon, the study area belongs together with other adjacent territories to a region of Lisbon, called "saloia", its old term, with which it established, from very early times, close interdependence ties with particular characteristics, such as architectural, social, cultural, amongst others. Moreover, this territory is situated in a geographical area considered by Ribeiro (1988) to be part of a transition zone, where the great contrasts of the ocean's presence and of the Mediterranean influence separate the country and come to dissolve.

The Lisbon Region lies in both the Atlantic and Mediterranean climatic zones, thereby enjoying a pleasant year-round temperate climate. Its mean annual temperature is 17°C, with average temperatures of 13°C in the winter and 27°C in the summer. Even when summer temperatures reach the mid 30ºC, the proximity of the Atlantic Ocean insures some cooling breezes. July and August are the hottest, driest months, while November to February is the most humid and coldest season. Sintra Mountains bound the north area of the Lisbon Region and host a series of climatic phenomena that result in considerably cooler, damper conditions than in Lisbon, with frequent mists that occur even in midsummer. It is precisely this climatic phenomenon that generates the rain conditions that feed the subsoil of the area under scrutiny with the water that subsequently also feeds the waters springs, water mines, water streams and water basins of this territory.

The soil in this area is constituted by a rich variety of geologic elements that were subject to diverse phenomena of volcanic, tectonic and sedimentary origins over different times. Such phenomena have contributed to shape the actual topography of this territory with a geographic structure that can be regarded as a plane surface modulated by water streams that cross it from north to south and that finally drains the continuous highlands situated northwards between Sintra and Montejunto Mountains. Such strategic situation of the mountainous area allows the taking hold of the oceanic air humidity and therefore granting the formation of clouds that are converted to rain, enabling the supply of water streams and the increment of the ground water levels. Fig.1 allows us to visualize such topographic structure, richly modulated by water streams that run from north to south.

This territory climatic condition, along with other natural circumstances, provides very different geographical environments and a rich landscape diversity, of natural and human occupancy, from which the greater area can be identified as being of Mediterranean characteristics.

It is our intention in this paper to provide a full geographical analysis of this area; instead, our goal is to demonstrate how the impact of subterranean and surface water determined specific urban morphological parameters of the Lisbon Territory.

3. Human occupancy and the morphology of the Lisbon Territory

Significant and valuable archaeological findings have proved that this territory of Lisbon must have been very attractive since very early times, such as the Palaeolithic period. The small inhabitant nuclei, positioned in the inner areas of this region, may have found their origin in the precarious tenancy of the Palaeolithic period or already in the Neolithic and Chalcolithic. Furthermore, they might have continued their establishment with a much more sedentary occupancy based on the "*Casais Agrícolas*" in the Final Bronze Age and in the Iron Age and, where these nuclei were finally found as inhabited settlements in the following periods, with a special prominence during Roman and Medieval occupancy, including the Muslim period, in a continuous occupancy that we venture to propose here.

As Lisbon was supplied by the 'saloia' region, other smaller urban centres within this region, such as Oeiras, Carcavelos or Cascais, also needed their own suppliers from the 'saloia' region, such as laundrywomen or sellers of goods and fresh produce. Thus, in a subsistence economy, of historical origins, for some 'saloios' there was in addition the trade of excess, the servant work in the closest urban areas or the employment as stonemasons, consigning to proximity a dependence that would endure over time (Cabrita and Marat-Mendes, 2007).

A long period of economic stagnation seems to have characterized the history of these urban settlements until very recent times; even Cascais' and Oeiras' promotion to "Villages of the Court", their XIX century development, along with the littoral developments as beach resorts, had little noteworthy influence in this sleeping inner region.

But it may have been exactly this extraordinary isolation that, at the same time, allowed the consolidation and emergency of the 'saloia' identity. Generally considered as descending from the Moorish populations that were banned from the re-conquered Lisbon, whom Afonso Henriques allowed to settle in his Term, it is more likely that their genealogy submerges into a variety of populations that have settled here, and that formed their character and appearance mainly through the long hospitality of several generations of Christians and Muslims (*idem*, *ibidem*).

Alongside with this isolation and the coexistence of ways of living based on a subsistence economy, most of the interior area of the neighbouring municipalities of Lisbon, situated in this 'saloia' region, have allowed the possibility to describe this territory's landscape as one of mere "villages and deserts" until the 1950's, as portrayed in the summary that a writer from the end of the fifteenth century makes of the country (Ribeiro, 1988:95).

Such "villages and deserts" were however a vast area of countryside spread out along the territory, and explored by different cultures through inherited knowledge as we have already stressed, but always according to the availability of resources, such as the sun, the soil and water. It was subsequently during the seventeenth and eighteenth centuries that, with the intensification of agriculture, mainly with olive trees and the promotion of summer houses and estates for nobility and royalty, that such "villages and deserts" witnessed a new transformation input into the landscape; without neglecting the most appropriate use of the available natural resources, nonetheless. The pattern that reflects such landscape is argued here as essential in order to dissect the morphological functioning of Lisbon's territory. Thus, in complement to Nunes' (2003) socio-morphological methodological approach, the present paper wishes to apply a morphological analysis of Lisbon Territory that places in evidence the territorial transformations against the natural resources management.

4. A morphological and environmental analysis of the Lisbon Territory

During the seventeenth and eighteenth centuries, the territory of Lisbon, which is under analysis here, witnessed the establishment of the Royal Estates of the Lisbon Region. We argue that these Royal Estates, together with other non-Royalty Farms, Farmhouses, Estates, Casais, Azenhas and other productive structures were strategically responsible for guaranteeing the sustainability of Lisbon's environments, whereas assuring a natural symbiosis between man, nature and the built environment. In addition, they simultaneously responded to human needs, territory urban arrangements, and natural resources availability and environmental constraints.

In an attempt to better understand this territory and its inherent morphological landscape, Marat-Mendes and Cuchí (2008) have provided an analysis of one of the water basins of the Lisbon territory, the Barcarena basin, providing an examination of farms distribution, crops production, and built environment and water availability along this water basin.

The analysis of the territory of Lisbon provided by Marat-Mendes and Cuchí (2008) refers to an application of a model of reading the landscape that is drawn up on a requisite of placing in relevance resources management.

Identification of the distribution of the farms along the Barcarena Basin was essential. Farms, farmhouses, estates, *Casais*, *Azenhas* and other productive structures were all identified over this territory. This is the same territory that during the eighteenth century supplied and fed the city of Lisbon, with its fresh produce, trade, services and material resources. Such identified structures represent the most visible elements of an elaborated management process of the territory biophysics materials matrix, which is characterized by the drainage of the water captured from the north mountain system located along Sintra and Montejunto Mountains (*idem*, *ibidem*).

The farms that until the 1755 earthquake had gradually witnessed the transformation of their main productive function into a residential one lead a complex production unit that incorporated various uses. Its main part usually presented an enclosed precinct, sheltered by walls, which provided protection for high-performance crops in opposition to the lower-performance crops, mainly cereal cultures, which in turn dominated all the other available territory. In addition to the main residence and its gardens, when they did exist, vegetable plots and fruit plots of various types occupied the above-mentioned walled spaces. These plots constituted the irrigated crops that assumed the use of the water resource as a flow that needed to be managed through the restrictive available conditions that the traditional systems could allow.

The dry land crops, the crops of lower-performance, exploited the infiltration of rainwater that fell directly on the ground with the help of farm operations, thus promoting competitors elimination and permeability of soil increment through tillage; therefore, ensuring their maximum availability for cultivation in moments of growth and maturation. Instead, the irrigation crop system or the crops of high-performance exploit the overflow and the infiltration that is not evaporated by the plantations, in order to concentrate water and to make use of it to fertilize exotic crops or crops of higher productivity.

However, this traditional water management system was conditioned by the use of the gravity power as the main element of water transport because, similarly to traditional societies, there was not enough power to systematically move the necessary quantities of water for agriculture. Thus, the capture, regulation and distribution of water were determined by the same geography of the territory, by the topography, the substrate, and the technical capacity for the management of the necessary elements for its government. As one defines these parameters, the availability of water also proves to be very diverse at different spots in the territory, whereas the potential for agricultural production under irrigation systems is differentiated (*idem*, *ibidem*).
If one assumes that in the eighteenth century there was enough market demand in Lisbon to take in the increases of the agricultural capacity of Lisbon's surroundings, and that neither the manpower nor the investment capital constituted restrictive elements, one must assume that, at that time, there was a maximum utilization of the opportunities that the differential biophysics matrix generated to establish irrigated crops in the area under study.

Only local constraints, such as the lack of access to distribution channels such as roads or some water streams, could justify the non-exploitation of plots or land that were positioned in places suitable for crop irrigation use.

Accordingly, the readings of the farms study disposition throughout the territory, at that time, should show which those spots were and how they responded to the availability of these factors through the dimension of the farm itself, the existing crops and the ability to capture water. Moreover, the work of Marat-Mendes and Cuchí (2008) considers the basin as the basic unit when considering the water flow, and therefore the basis of any analysis of sustainable development for any planning practice purpose.

5. The Barcarena water basin

The analysis of the Barcarena basin developed by Marat-Mendes and Cuchí (2008) was undertaken throughout the basin identified by the Barcarena River and its respective effluents.

The total area covered by the Barcarena basin is approximately 35 Km². In the whole basin area of Barcarena 18 farms were identified that occupy a total area of 1.56 Km^2, as indicated in Table 1. The methodology that was adopted for the Barcarena basin analysis consisted of the application of Marat-Mendes and Cuchí's (2008) methodological approach. However, the analysis that is now presented consists in an updated analysis provided after posterior investigation. All the available cartography for the 1893 to 1898 time span refers to cartography from the Corpo do Estado Maior that was analysed in order to provide a full scrutiny of the different farms spread all over the Barcarena basin territory.

The cartography, at the 1:20.000 scale (Corpo do Estado Maior), exhibits an evolution of this territory that is reflected by the appearance of new farms in 1898 that were not present in cartography from 1893. It is possible to identify three farms that were not indicated in 1893. These are the farms Q. do Jardim, Q. da Moira and Qt.ª do Jardim. The latter two farms indicated as non-productive farms must have been found based on a leisure background and not on a productive perspective, as all the majority of the identified farms.

Table 1. Farms in the Barcarena Basin

Farm Name	Farm Area (m^2)	Highest Level (m)	Basin area (m^2)	Solar Orient.	Observations
Q^{ta}. Real	69313	30	511 391	SW	Trees/garden/pine trees, 1 fountain
Q. do Jardim	18 865	20	1 170 376	NW	Olive trees (7), 1 wind mill
Q da Moira	4 257	50	172 197	SW	Non-productive. No existence in 1893
Q^{ta}. do Porto	162 321	190	1 276 283	S	Olive trees (5), other trees (exotic), worked land (4), No existence in 1893
Quinta da Maria do Ó	175 709	160	782 426	SW	Olive trees (4), pine trees (5), worked land (7)
Q^{ta}. do Malhapão	245 483	180	3 440 282	S	Trees (13), worked land (5), 1 well
Q^{ta}. do Minhoto	22 561	190	281 180	S	Non productive
Q^{ta}. do Telhal	128 574	190	4 848 236	SE	Olive trees (13), worked land (3)
Q^{ta}. do Café Concerto	59 990	240	190 760	S	Non productive
Unnamed (at Queijas)	8 542	80	830 496	SW	2 trees, 1 well, No existence in 1893
Qtª do Jardim	128 779	30	2 062 293	SW	Non-productive, 1 wind mill
Unnamed	24 747	80	516 386	SE	4 trees
Unnamed	48 111	150	527 331	E	6 trees
Unnamed	34 452	170	270 546	E	Non productive
Qtª dos Loyos	143 189	170	257 029	E	Olive trees (15), near the river
Unnamed	241 833	220	271 480	SW	Pine trees (28)
Unnamed	18 803	210	135 071	SW	Non productive
Unnamed	21 758	160	184 914	S	5 trees

Source: Teresa Marat-Mendes[3]

The adopted methodology that was followed to analyse the Barcarena Basin, and whose results are present in table 1 was the following one:

a. Delimitation of the Barcarena Basin;

b. Identification, delimitation and categorization of all walled farms in the Barcarena Basin. These farms include those indicating name or not (unnamed farms). From the group of identified farms we identified in Barcarena three types of farms: 'Qt.ª', 'Q'. and 'Quinta';

[3] The author would like to thank Hugo Meireles for his work in the preparation of the Barcarena Basin Analysis.

c. Analysis of all identified Farms, which included the identification of each farm in terms of: highest topographic level, solar orientation, type of crop and number of elements present in the cartography, and any other elements such as fountains, wells, mills, etc.;

d. Identification of each farm's respective water basin. This was achieved by considering the geometry of the territory situated above the farm's highest topographical level;

e. Evaluation of the different farms' water basins according to their size, position and relation to other farms located in the Barcarena Basin.

Each farm's water basin corresponds to the amount of territory that each farm intercepts, or finds available, to retrieve its own water. When the farm is situated nearby a river, it was considered that it probably shared the water of its basin with the other farms that are in contact with that same basin.

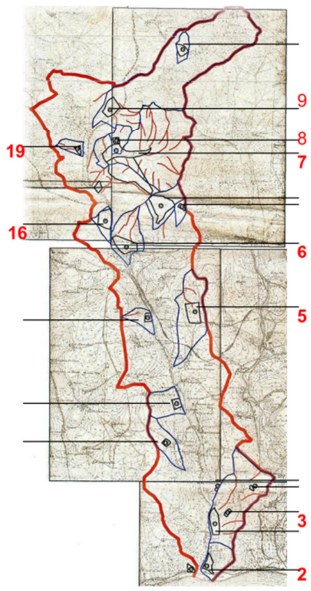
The other potential water abstraction source for the different farms was the possibility to exploit subterranean waters, fed by aquifer-infiltration throughout water quarries, mines or springs that accessed such waters. Those quarries partially enabled to surpass the restrictions imposed by the biophysical matrix, while allowing water transportation, and therefore surpassing the natural geometry of the water basin. The water quarries supply was a generalized system in this region, a pre-existence that allowed in that same century, the eighteenth century, the transportation of water for urban propose uses to the capital, Lisbon, through the construction of the "Águas Livres" Aqueduct and its subsequent expansion and development. As the quarries only operated through the use of gravity force, only territories situated above the higher level of the farm can be considered as a source of water supply (Marat-Mendes, 2007).

Aqueducts, accurately identified in the cartography under analysis, indicate the presence of water transportation between the different basins of the Territory of Lisbon. This demonstrates how the productive work established by the biophysical matrix can result differently when in presence of technical elements, despite natural restrictions such as gravity.

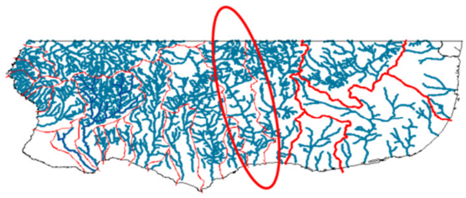
The analysis of the disposition of each farm's own basin throughout the basin area of Barcarena demonstrates that the farms' basin areas vary considerably. For the total area of the Barcarena Basin, approximately 35 Km^2, the total area covered by farms' basins is 20.25 Km^2. This means that almost 58 percent of the area of the Barcarena Basin was being used by farms in order to intercept the necessary water to sustain them. Yet, only 4 percent of the Barcarena basin is covered by walled farms, that is to say an area of 1.56 Km^2. This situation reveals a high level of competition for water supply. Indeed, it was not possible to expand the number of farms as that would compromize the access to water supply.

Wherein the smallest farm's own basin measures 135,480 m^2, the largest one measures 4,646,864 m^2. Yet, the first one corresponds to a non-productive farm and the latter to a farm with various types of crops and trees. The disposition of the farms' basins within the Barcarena basin allows only two situations of different farms' basins overlaying. Such situations are nonetheless unusual since, according to the farms disposition, each farm saves its own basin for its own water supply system. The identified situations are the flowing: the first one refers to the overlay of Q. do Malhapão's own basin and the Q. do Minhoto's own basin; the other situation refers to the overlaying of the Q. do Telhal's own basin with the Q. do Café's own basin. Interestingly, the two overlaying situations only occur because of the presence, in each case, of one basin of greater dimension, as the basin of Q. do Malhapão and the basin of Q. do Telhal. Also, the dimensions of their respective farms are very generous. In addition, such situation might be also explained as Q. do Minhoto and Q. do Café do not report any crops exploitation in the available cartography. Thus they were non-productive farms. All the other farms' basins are independent and do not share different farms.

Figure 2. The Barcarena Basin and its identified farms. The Barcarena Basin within the territory of Lisbon.



ID	Name	Area of the Farm [m2]	Highest level	Area of the Farm Bay [m2]	Solar orientation
2	Qtª. Real	69 313	30	511 391	SW
3	Q. do Jardm	18 865	20	1 170 376	NW
4	Q. da Moira	04 257	50	172 197	SW
5	Qtª. do Porto	162 321	190	1 276 283	S
6	Quinta da Maria do Ó	175 709	160	782 426	SW
7	Qtª. do Malhapão	245 483	180	3 440 282	S
8	Qta. do Minhoto	22 561	190	281 1180	S
9	Qtª. do Telhal	128 574	190	4 848 236	SE
10	Qtª. do Café Concerto	59 990	240	190 760	S
11	sem nome - Queijas	8 542	80	830 496	SW
12	Qtª. do Jardim	128 779	30	2 062 293	SW
13	Sem Nome	24 747	80	516 386	SE
14	Sem Nome	48 111	150	527 331	E
15	Sem Nome	34 452	170	270 546	E
16	Qtª. de Loyos	143 189	170	257 029	E
17	Sem Nome	241 833	220	271 480	SW
18	Sem Nome	18 803	210	135 071	SW
19	Sem Nome	21 758	160	184 914	S



Source: Teresa Marat-Mendes.

Regarding the farms' dimensions, the table leads us to conclude that there is also a great variety in the farms areas. Whereas the smallest one measures 4,257 m² (Q. da Moira), the biggest one measures 245,483 m² (Qta. do Malhapão). Nevertheless, in the smallest farm, its inherent basin is not necessarily the smallest one, although it is small when compared with all the other basin areas. However, the ratio between the basin area and the farm area does appear to be all important, since in the second smallest farm, its inherent basin area is however very generous when compared to the basins of larger farms. Furthermore, there is also an apparent relationship between the disposition of the farms throughout the territory and their own size. The biggest farms are usually concentrated in higher-up areas, mostly between 220 and 180 m above sea level, when compared to those situated at lower levels. Regarding the topography, the farms also seem to prefer the south-western slopes of the Barcarena basin, followed by the southern and eastern orientations, thus benefiting from the sun, while situated preferably facing southwest.

The total amount of surface area covered by the different farms' own basins covers 58 percent of the total surface of the Barcarena basin. And, if one takes into consideration that almost all the farms are situated at the south-western side of the Barcarena basin, then one should bear in mind that the utilization of this basin is quite intense. This means that farms were placed exactly where they needed to be. From the 18 identified farms, only one of them is situated on the northwest flank of the Barcarena River, and that is the case of Q. do Jardim, that in turn is located at the lowest level of the Barcarena Basin, at 20 meters above sea level. This farm is located in a flat area, although with a generous basin area when compared to other farms.

Indeed, all other identified farms represent examples of walled farms that were, apart from Q. da Moira, walled precincts for crops protection purposes. The farms situated in the highest grounds which also presented generous basin dimensions, reveal at the same time a great variety of crops that include olive trees, vineyards, and diverse fruit trees. The unique farm that was situated at the same height level, albeit the smallest in overall size, is Q. do Minhoto. This farm does not report any crops production, but interestingly its basin area is the smallest one when compared with the other basin areas of farms situated above the 160 m above sea level.

In order to exemplify how the different walled farms were organized in the Barcarena Basin, Fig. 3 illustrates the plan of Real Quinta de Caxias. This Royal Farm deserved special attention while being subject to a plan analysis that other farms (non-royal ones) of this same territory did not witness. This farm belongs to the category of

Royal Farms that were all analysed in detailed plants conducted by Capitão Engenheiro J. A de Abreu, Vogal Secretário Comissão do Tombo dos Bens da Corôa, in 1844. See, for exemple, in the Territory of Lisbon also Planta do Real Palácio e Quinta de Belém, Planta da Real Quinta do Calvário, Planta do Almoxarifado do Paço, Planta da Real Tapada da Ajuda e Planta do Real Paço e da Villa de Cintra, all available at Biblioteca Nacional de Portugal.

The way that Real Quinta de Caxias was structured in the interior of its precinct area makes us realize how all the other farms were also likely to be organized, including the non-royal ones. The main assumption is that the building techniques such as infrastructures and farming techniques, even if not as elaborated as in a Royal Farm, would be the same in use everywhere else. In this sense people would replicate these techniques in the organization of its urban and rural territory according to the natural resources that were in use, but also to the available building and infrastructure techniques in use. Quinta Real de Caxias' plan enables the identification of how the farm was organized in its inner area: it included buildings, farm walls, tanks, aqueducts, fountains, pedestrian paths and a garden boulevard network; moreover, the plan also displays the farm's relationship to its immediate environments, such as the Tagus River and Rio de Barcarena, to the coastal line and neighbouring roads. Likewise the plan indicates the different crops types and their distribution inside the farm and outside its wall limits.

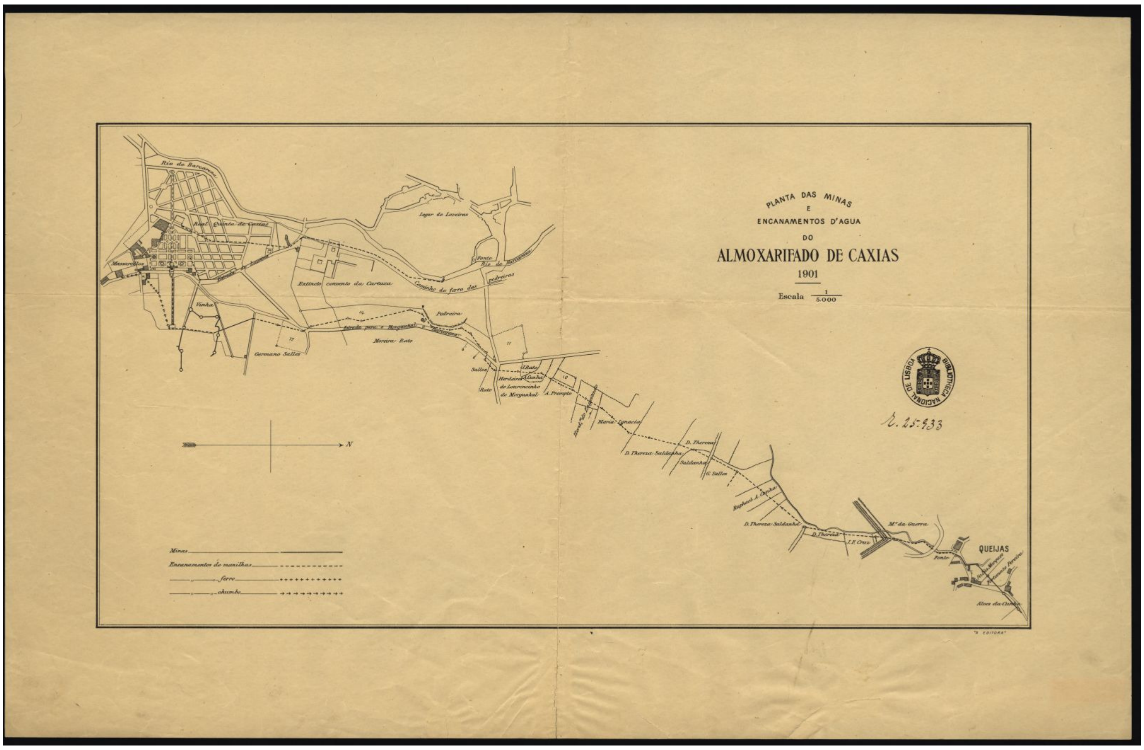
The Plan 'Planta das minas e encanamentos d'água do Almoxarifado de Caxias', was carried out in 1901 and exposes the subterranean aqueduct that sustained Real Quinta de Caxias with water from a spring located in Queijas, outside the Barcarena basin. A detailed analysis leads us to identify two water springs initially explored to sustain Real Quinta de Caxias with water.

Figure 3. Plan of Real Quinta de Caxias

Source: J. A. de Abreu; picture by A. J. L. Dinne. (scale 1:1000). Lisboa: Lithografia de A. C. Lemos. 1884.[4]

[4] Available at http://purl.pt/1392, courtesy of Biblioteca Nacional de Portugal.

Figure 4. Plan of the quarries and aqueduct system that provided water to Real Quinta de Caxias



Source: Cartographic material (scale 1:5000), Lisboa: A Editora. 1901.[5]

6. The twenty three water basins of the Lisbon Territory and the real scale of Lisbon's urban environment morphological anatomy

While adopting Marat-Mendes and Cuchí's (2008) proposed methodology in the Barcarena water basin analysis, we aimed to identify the relationships between the environment, urban form arrangements and land distribution. This paper will now introduce a broader analysis of Lisbon's Territory that was established through a method of territory analysis that bears also on the notion of Sustainable Urban Form as defined by Marat-Mendes (2002). Wherein a Sustainable Urban Form is defined as an urban form that has the capacity to survive processes of change – and that at the same time provides an environmental quality that responds to the variety of needs over time – time, space and change appear to be the principal elements to be considered in any analysis of sustainability account.

We will now introduce the analysis of the territory of Lisbon, constituted by a total number of twenty three water basins, which has followed Marat-Mendes and Cuchí's methodology of water basin analysis. The evidence of this analysis' results and application hopes to demonstrate that it is possible to promote a broader awareness of the need for more detailed territorial analysis in order to better implement principles of sustainable urban environment and urban form, as already claimed by Garrabou (2006) and Guerra (2010). Moreover, further comparative analysis of these results with other similar territorial analysis would provide: i) a cartography of territorial *versus* natural environment relationship behaviours; that would provide ii) a comprehensive understanding of the urban and rural environments' behaviours, that would iii) better inform urban planners decisions; and iv) provide new questions and perspectives regarding planning history and current planning practice methodologies and tools, as claimed by Ábalos (2008).

[5] Available at http://purl.pt/1752, courtesy of Biblioteca Nacional de Portugal.

Supported by a strong environmental and ecological perception, the proposed methodological framework for the analysis of the twenty three water basins of the Lisbon Territory consisted of two main features: i) the analysis of the territory; and ii) the recognition and identification of its morphological structure.

The analysis was based on information provided by the military maps of the surroundings of Lisbon from 1893-1899 at the scale 1:20.000 (Corpo do Estado Maior, 1893-1899), thus enabling the establishment of the farms' disposition throughout the territory. More current cartography was also used in order to allow a comparative analysis between the 19th century information with the contemporary data.

The different steps covered throughout the methodology were the following ones:

a) Delimitation of the analysed territory throughout its natural features;

b) Identification and delimitation of the twenty three water basins that constitute the area under analysis;

c) Recognition of the natural conditions of the water basins: geology, topography, hydrology and climate;

d) Identification of the water basins' human and physical conditions: urban agglomerations, types of farms, road systems, types of uses;

e) Delimitation and identification of the different walled farms located in each water basin;

f) Identification of each farm's water basin, defined according to its geometry and localization in the territory situated above the farm's highest topographic level;

g) Identification of the types of crops and their location in every identified walled farm;

h) Analysis of landscape use (through occupancy type and crops) regarding its distribution throughout the territory in analysis, and finally the establishment of some final remarks, throughout a comparative analysis between the twenty three water basins.

The analysis provided the identification of several walled properties, which can be organized in different categories or types. These corresponded to the different designations that were found for the several walled properties, namely, "Qta.", "Q." and "C.". Following an analysis of the areas of these properties it was possible to identify several differences in their areas. While the "Qta." Have an average area of 130,000 m^2, the "Q." has an average area of 51,000 m^2, and the "C." approximately 14,600 m^2. Moreover, while the number of properties designated with a "C." is relatively reduced while compared to the other two cases, we can conclude that such designations have a correspondence to the properties areas.

The analysis of the territory has also allowed the identification of other properties, however these are not walled ones. These non-walled plots were not considered for the comparative analysis, as they do not represent high-performance crop plots, as defended by Marat-Mendes and Cuchí (2008), and therefore these non-walled plots do not assume the use of water resources as a flow that needs to be managed, and therefore an important morphological element of urban planning. Only the walled properties or plots were therefore considered for this analysis. Interestingly, these were greatly found under the contour line of the 250 m height of this territory, predominantly between the 0 m and 50 m topographic levels. This situation might owe to the area of each farm's own water basin: the lowest the level of the farm, the greater its own water basin will be.

Within the twenty three identified water basins it is in basins 21 (Barcarena Basin), 22 (Jamor Basin) and 23 (Algés Basin) that one finds the concentration of a greater number of farms. Each one of these basins covers more than 20 farms. Interestingly, these are the basins that are closer to the city of Lisbon.

The location of the farms is concentrated throughout the two main route accesses (Lisbon-Cascais) and (Lisbon-Sintra). The first one is situated closer to the Tagus river banks and the second one is where the water streams initiate their course. Other farms, however, are located along the north-south water streams that run through each water basin, although in a much more reduced number.

Around the Sintra Mountains it is also possible to find a great concentration of farms, located in its foothills, approximately at the 200 m level, concentrated in three main locations: where the mountain faces south, north and on its top level (510 m height). This last location congregates the farms that have greater areas. However, due to the aggressive natural conditions, such as altitude, accentuated topography and the Atlantic influence, the farms located on the Sintra Mountains have as principal crops mainly pine trees and other trees.

Another concentration of farms is localized in the area of Oeiras, close to the Marginal (the route that connects Lisbon to Cascais). The majority of these farms belongs to Marquês de Pombal (the Count of Oeiras). In this same area, it is possible to identify good quality soils, great solar exposure in a flat slope, thus favouring the vineyards plantation.

Regarding the types of crops identified in the entire area under analysis, one can identify pine trees, olive trees, assorted trees, vineyards and also farmed land. These designations are provided in the analysed 19th century cartography (Corpo do Estado Maior, 1893-1899).

The larger number of crops production is found at the 250 m level. Above that level the crops production is almost non-existent, except for the growth of pine trees and other trees; these are crops that did not depend on watering subsistence. Vineyards are located in farms situated under the 150 m topographic level, registering however a prevalence at the 50 meter-high level. Preference seems also to be given to territories that face a southern solar exposure. Only one vineyard faces north, and that is located on the Sintra Mountains. In terms of the growth of trees, there is no information regarding their species, but we were able to find a great concentration of farms where trees grew between the 100 m and 150 m levels (60 percent of the identified farms). The other farms that report the existence of trees are dispersed at different levels, albeit having a greater predominance in water basin number 9 (Ribeira de Colares basin). Moreover, there is no predominant solar exposure.

Olive trees are predominately located at 100 meters above sea level; and there is no presence of this type of tree above the 250 m height-level. This crop is constantly associated with the farmed land identified crops. There is also no predominant solar exposure for this type of crop. Finally, the farmed land appears to be located always associated to the growth of other types of crops, and is mainly located at the lowest levels (below 250 m), with a greater predominance at 50 m above sea level. The reason for this situation might be the need for watering and the need for the biggest farms' own water basins, which are precisely located at the lowest levels.

Regarding all identified farms, 37 percent of them do not have any indication of crops. There might be two reasons for this situation. One should correspond to the abandonment of the farm, while the second reason has to do with the use of the farm that might be of a leisurely nature, as summer houses, instead of a productive use. The summer houses were very common during the 18th century. And, this possibility is coherent with the great number of farms without crops type identification and farms of smaller dimensions that we encounter in water basin number 23 (Algés basin), the one located closest to Lisbon.

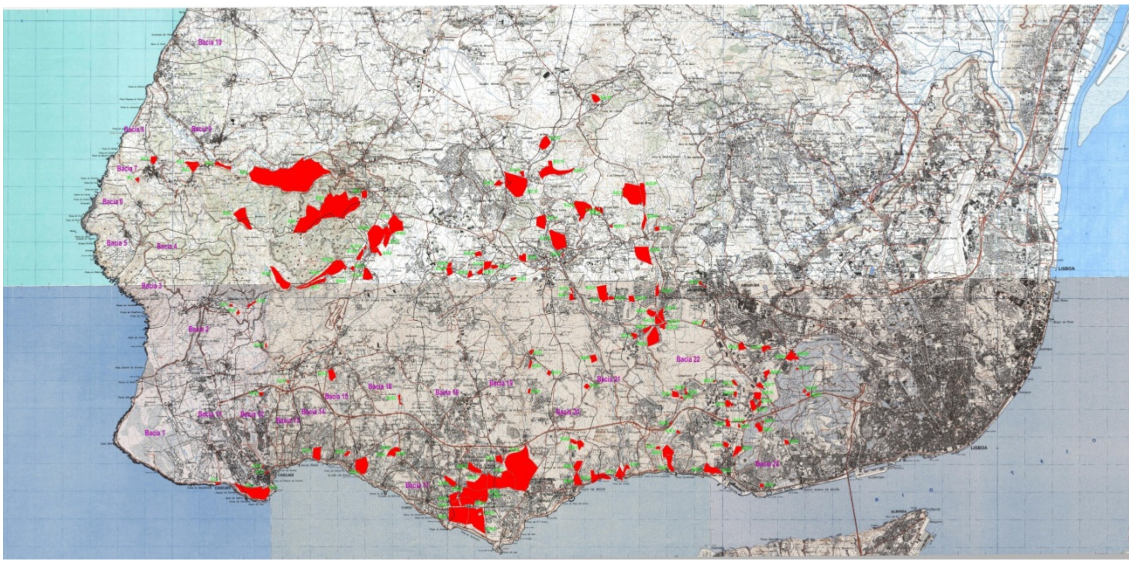
Summarizing, basins number 18 (Maradas basin), 19 (Lage basin), 20 (Porto-Salvo basin), 21 (Barcarena basin), 22 (Jamor basin) and 23 (Algés basin) are the ones that present a greater number of productive farms, mostly favoured by its proximity to Lisbon and to the regularity of its topography and southern solar exposure.

From the analysis of the road systems and urban nuclei, identified in the 1893-1899 cartography, one can deduce a close interdependence between them and the farms location. The principal routes refer to the rail trail structure and the two main axes of access for both principal routes Lisbon-Cascais and Lisbon-Sintra. Secondary roads that run perpendicular to the main routes, along the top levels of the identified water basins, make the connection between these two principal routes.

Regarding the analysis of the road system and the existing urban nuclei with the identified farms on the cartography of 1893-1899, one finds the permanence of the former roads and urban nuclei until present times. However, more recently, it is possible to identify the presence of a third road emerging between the two previous identified main axes. This route refers to the new motorway that was built during the 1980's generating the expansion of new urban areas along its route (A5 motorway). Thus, allowing the occupancy of a less occupied territory inherited from the 18th century.

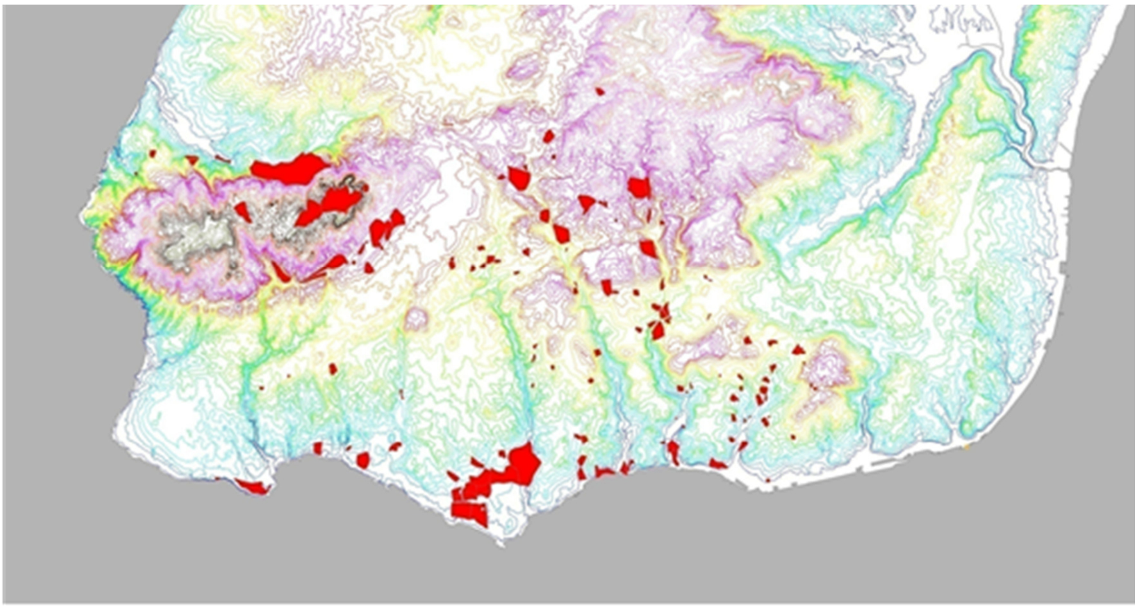
The analysis of the 1893-1899 cartography has enabled the identification of land use rules that regulated this territory occupancy since the 18th century, while urban development, however, was undertaken according to an idea of natural resources management synchrony.

Figure 5. Identified farms over the territory of Lisbon



Source: AA.VV, under the supervision of Teresa Marat-Mendes[6].

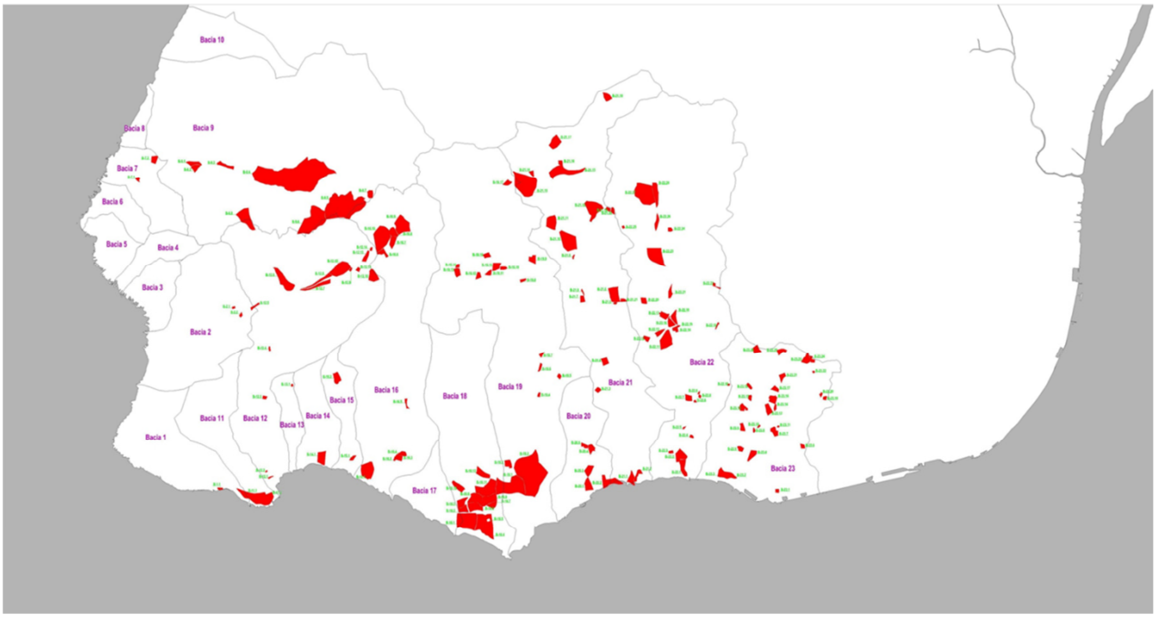
Figure 6. Lisbon's territory hypsometry and location of the farms



Source: *idem*, *ibidem.*

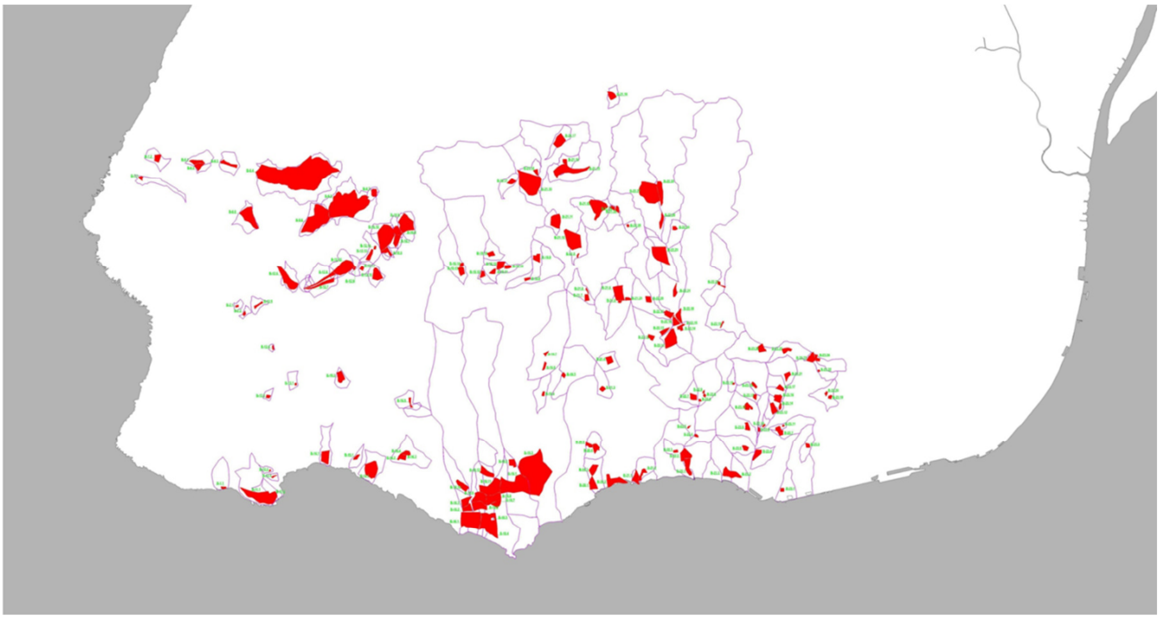
[6] Prepared with the support of the students of the Master's Course in Architecture, at the Department of Architecture and Urbanism of ISCTE – Lisbon University Institute, for the course of Ecology and Territory (2007/2008), Liliana Vieira, Luciana Lameirinhas, Mário Nunes, Paulo Saiote and Susana Santana, supervised by Professor Teresa Marat-Mendes.

Figure 7. Lisbon's territory and the identified water basins of the study area, including the analysed farms



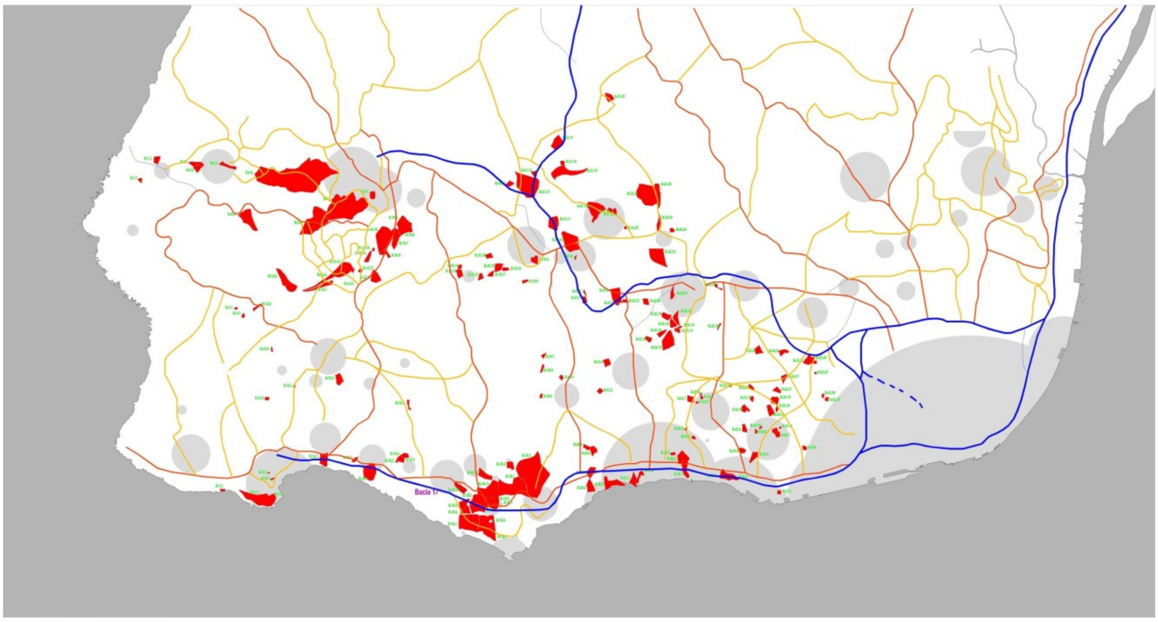
Source: *idem*, *ibidem.*

Figure 8. Each farm's own water basin over the territory of Lisbon under analysis



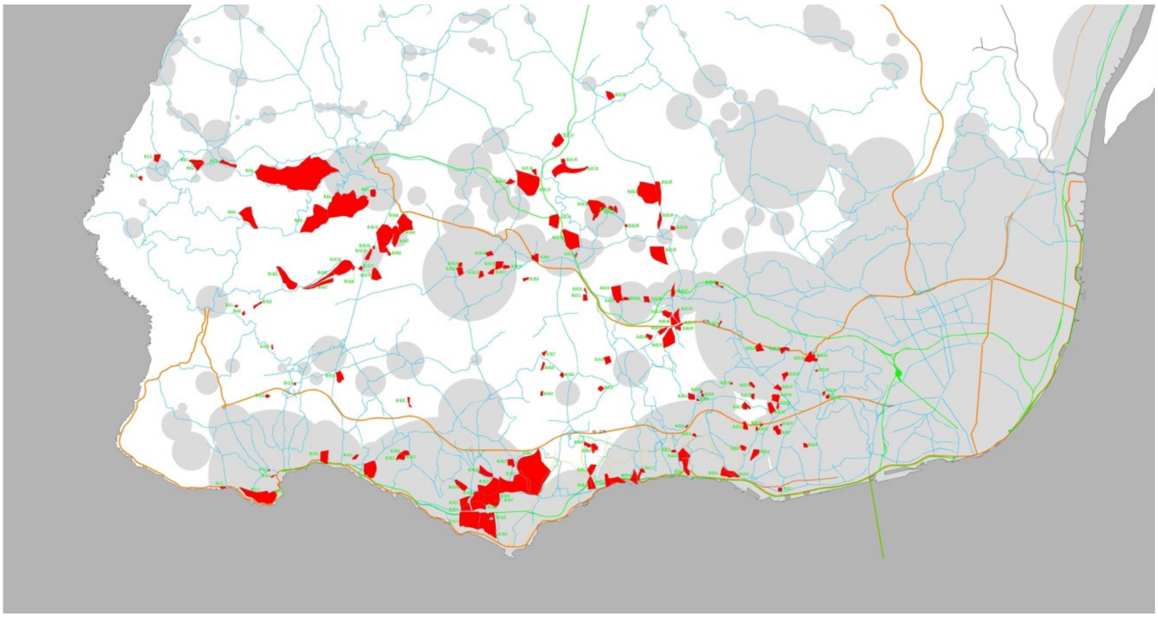
Source: *idem*, *ibidem.*

Figure 9. Location of the old urban nuclei, main roads and farms



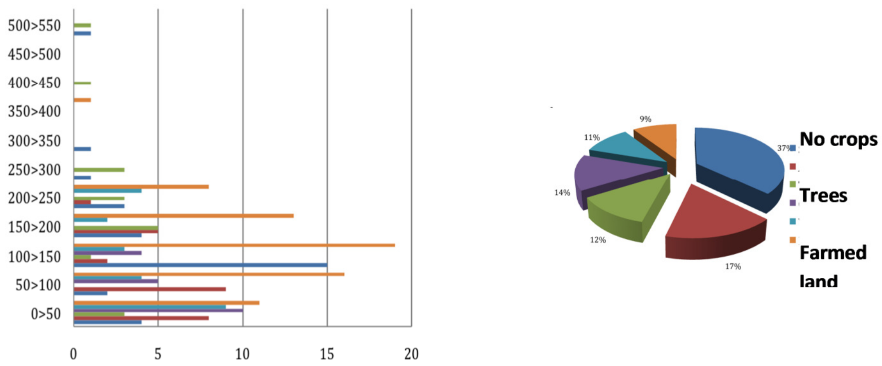
Source: *idem*, *ibidem.*

Figure 10. Location of the contemporary urban nuclei, main roads and farms



Source: *idem*, *ibidem.*

Graphic 1. Connection between type and number of crops per altitude level (meters)



Source: *idem*, *ibidem*.

7. Conclusions

This work has shown different ways of approaching landscape analysis as adequate tools to read and understand the traditional productive systems of such landscapes, which in the end is the expression of the resources management model that used it. Moreover, it reflects on the need to better understand landscape when environmental enhancement is demanded for urban form improvement. Indeed, urban form, when resulting from a parcelling inherence, even if it refers to rural uses, reflects previous models of land use that need to be better perceived in order to extract the lessons for environmental control.

As one can conclude from the analysis of the twenty three water basins identified in the western region of Lisbon's Territory, the previously isolated territory, as defined by Marat-Mendes and Cabrita (2007), was subject to agricultural intensification during the 18th century, as confirmed by Marat-Mendes and Cuchí (2008) for the Barcarena water basin. Therefore, such agricultural intensification responded to an urban and rural parcelling order that reacted however to a model of natural resources management, wherein water was the main resource. Moreover, the distribution of farms over the territory implied a competition for water resources which has determined the shape, size and location of the different farms throughout this territory. The limits of territorial organization were defined by the natural conditions of the site, as well as by the available techniques of natural resources management, as with the aqueducts. Moreover, it was after the abandonment of the agricultural production use that the loss of this logic of territorial organization occurred and contributed to an environmental disorder of the natural resources management.

According to Marat-Mendes and Cabrita (2007), the parcelling structure of this territory's interior area was kept almost intact until the end of the first half of the twentieth century. It was mainly through the introduction of the new motorway structure that major changes performed great alterations to the original parcelling structure. The frozen situation of such parcelling structure did however ensure, in the Lisbon territory, the functioning of its natural conditions, including its natural hydrological system until the 1960's. This factor is also a result of the inherence provided by the seventeenth and eighteenth century farms territorial arrangement. Therefore, if improvements of the natural conditions of the site need to be done in the future, a better acknowledgment of the previous resources management model and its intrinsic parcelling structure needs to be achieved.

In order to better respond to a more positive relationship between the Natural Environment and the Urban Form, the scale of analysis that should be used is therefore important to ascertain. It concerns not only the scale of natural resources that flow in the territory under analysis, and that determine the physical constrains of the natural system, but also the scale of change that this territorial structure can absorb while ensuring the closing of the material cycles that occur over it. Thus, landscape seems to be the real scale to approach urban form and the environment.

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