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Bioclimatic Approach in Municipal Master Plan
The Northern Part of Portuguese Western Coast

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Abstract
Energy consumption in Portuguese buildings has been increasing over the last few years, at an average annual rate, from 1990 to 2000, of 3,7%, in residential buildings and of 7,1%, in services buildings. This trend goes against the objectives established by the European Commission for the year 2010, whose purpose was to reduce by 20% energetic consumption in households [1].
Apart from the relevance of the thermal quality of buildings' envelope, which is regulated since 1991 by the Portuguese Building Thermal Regulation (RCCTE), it is a well-known fact that urban planning can play a very important role in the creation of favourable microclimatic conditions, for the improvement of energy efficiency in buildings, as well as for the attainment of thermal comfort in public spaces.
This work intends to present strategies and explore the advantages of adding bioclimatic principles to land use plans for the northern part of the Portuguese western coast. It will try to demonstrate that a Municipal Master Plan without bioclimatic concerns can lead to an inadequate urban design practice. A plan with these concerns lays down special requirements to ensure the equilibrium of an intervention in a given location, taking environmental agents into account. It is important to establish and gather essential guidelines for a correct urban environment for the buildings in order to achieve energy efficiency and to optimize the quality of the urban environment from a bioclimatic point of view and, consequently, to promote environmental sustainability.
This paper presents the results of some preliminary tasks of a wider research work that is being carried out at the University of Porto, Portugal.
For a specific area of the Portuguese coast, a diagnosis of the existing land use and a draft definition of strategies will be presented.

1 Introduction

The Portuguese municipal land use planning system includes the Master Plan, the Zoning Plan and the Local Plan, in a well defined hierarchy.

The Master Plan (MP) is an instrument of municipal scope that regulates land use, prospecting demographic and economic growth, managing natural resources, establishing parameters of adequacy of construction, built-up density, types of use and types of construction.

Land development according to urban sustainability standards needs, more and more, a bioclimatic approach in all stages of the process, from the planning phase to the construction of the town. The bioclimatic approach requires a wide and complete multi-expertise study, very much beyond the search for building thermal optimization or for comfort in public spaces. Thus, cooperation between different experts is fundamental, in order to achieve a global effective intervention on the land.

Therefore, we must establish different levels of diagnosis and analysis, from geomorphology to social aspects of land use, in order to integrate, coordinate and organise land use, according to urban sustainability purposes, in particular, as regards the search for an appropriate response to the climate.

The definition of an adequate bioclimatic strategy for the area we will study in this work requires the analysis of all fundamental climatic data, where the most important are solar radiation (solar altitude, number of hours of sun exposure, etc.), and the prevailing winds (direction and speed). These climatic characteristics strongly affect, in a specific context of outdoor temperatures, the attainment of an energy efficient behaviour for the buildings and of thermal comfort in urban public spaces.

2 Climatic and topographic characterization of the territory

The area that was chosen for the study that is being carried out is the one of the northern part of Portuguese western coast, between Espinho and Caminha. In this paper, we will focus on a more limited area, in the municipal border between Espinho and Vila Nova de Gaia, along the coast. A map with the location of the area is presented in Fig. 1.

In Fig. 2, we can see the part of the coast that we will analyze, located at the boundary between the Espinho and Vila Nova de Gaia municipalities.

Fig.3 gives us a wider aerial view.

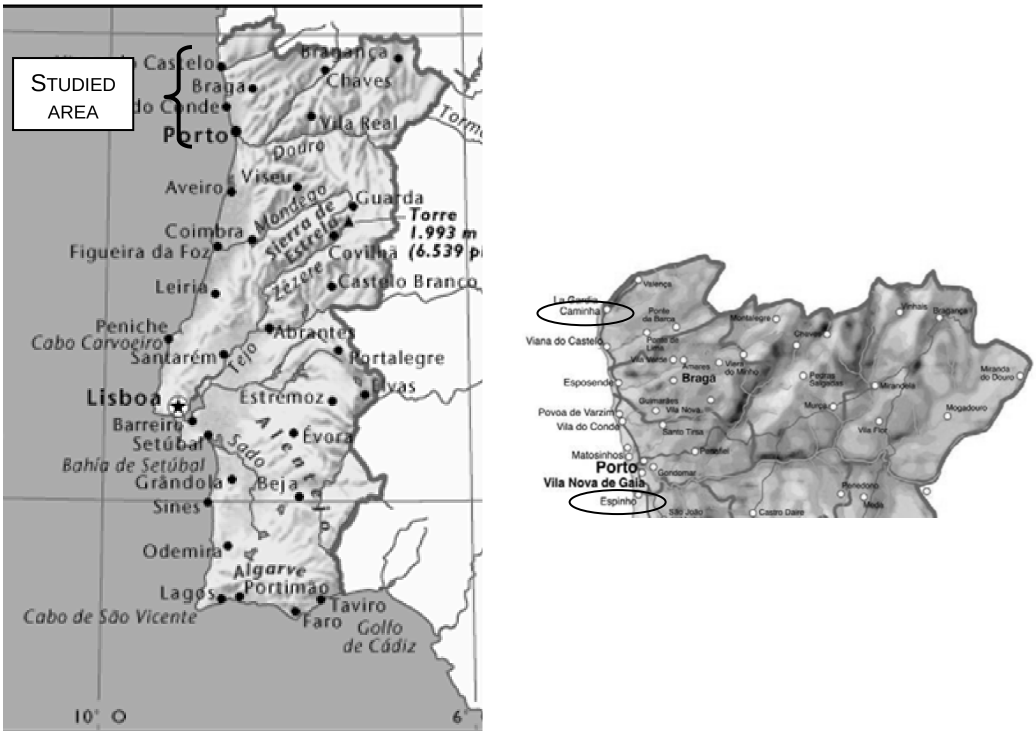

Figure 1: Location of the area that will be analyzed within the Portuguese territory

Figure 2: View of the coastland

Figure 3: Aerial view

This area is located at a latitude of about 41º N, and is characterized, in topographic terms, by an amphitheatre shape facing West, with smooth and progressive slopes and considerable sun exposure. Integrated in the Metropolitan Area of Porto, the second major Portuguese town, the area can be climatically characterized, in general terms, by the data collected for Porto.

The annual mean of daily global irradiation on a horizontal surface is about 4,4kW.h/m^2. The monthly mean of the same parameter is about 1,7 kW.h/m^2, in January and 7,2 kW.h/m^2, in July [9 quoted in 6]. The mean value of the monthly minimum temperature varies between 4,9 ºC, in January and 14,9 ºC, in July and the mean value of the monthly maximum temperature varies between 13,1ºC, in January and 24,7ºC, in August, as we can see in Table 1.

Table 1: Temperatures in Porto [3]

Temperature in °C	January	February	March	April	May	June	July	August	September	October	November	December
Mean value of monthly minimum temperature	4,9	5,5	7,1	8,7	11	13,6	14,9	14,7	13,9	11,1	7,8	5,7
Mean value of monthly maximum temperature	13,1	13,9	15,7	17,5	19,4	22,3	24,3	24,7	23,6	20,4	16,1	13,6

From May to September, the coast suffers the action of maritime winds coming from West and Northwest (these one known as "*Nortadas*"), with high levels of moisture and saltpetre. In the remaining months the prevailing winds blow from East and Southeast.

The seaside maritime currents are cooled down by the deepwater currents, which are rather cold, ("upwelling" phenomenon), affecting the air mass coming from West, causing the common fog during summer time (June to September), which lasts often almost all day long [3].

The climatic characteristics are clearly different in the interior from a distance of 1km, partly due to some barriers of pine groves that still exist, thanks to which the *Nortadas* subside and the fog lifts in the summer months.

3 Diagnosis and critical analysis of the existing land use

Until the beginning of 20th century, this coastland was protected by dunes, vegetation and local trees, which controlled the violence of the winds coming from West and Northwest, between May and September, reducing its speed and intensity. Urban settlements were developed near the maritime coast, but they were sufficiently protected by the pine groves in a first line of protection until the end of the 19th century. With the growth of small housing clusters belonging to fishermen and later on, with the implementation of the railway line, the first summerhouses of wealthy families appeared in the beginning of the 20th century.

After the end of the dictatorship, the populations started building illegal houses in a disordered and uncontrolled way, enlarging the perimeter of the small seaside settlements and building progressively nearer to the beaches, removing dunes and local tree species.

During the 1990s, the Portuguese northern maritime coast underwent a significant and uncontrolled boom, because people were searching for places with a good view to the sea.

This intervention area, which is located near a consolidated urban centre, Espinho, was the result of successive decentralization processes, which promoted rapid growth without the necessary regulation and coordination with territorial management instruments. This growth led to the loss of the urban and demographical characteristics of the region.

This area, which lays under the scope of a very recent Master Plan with a short application experience, suffered an extreme densification of land use, particularly in the maritime front line, having, therefore, gone through a big transformation, with environmental urban damages in terms of the quality of use of public spaces and precarious general constructive quality of the buildings along the coast.

The main negative aspects that were detected, from a bioclimatic point of view, were the following:

- Construction of concrete corridors that, for this climatic scenery, work as wind tunnels and thus worsen climatic elements and create the conditions for inadequate shadowing over streets and buildings, without any concern to promote adequate spacing;
- Uncontrolled penetration of sea winds, with high levels of moisture and salinity, leading therefore to more wear and tear in the constructions themselves;
- Destruction of old pine groves, which, together with the absence of vegetation along the coast, does not allow the reduction of wind in the area;
- Absence of bioclimatic strategies as regards the design of new blocks, with wrong options in the dimensioning, orientation and shape of the buildings, giving preference to economic and feasibility factors; these solutions do not guarantee a proper solar exposure, favouring the propagation of sea winds in the summer and South-eastern winds in the winter;
- Existence of streets unprotected from the wind because of the absence of trees;
- Absence of protection galleries in the main pedestrian courses;
- Compromising of potential bioclimatic strategies adopted in architecture, because of an inadequate urban framing, originating bad thermal conditions in the building(s).

The combination of the above-mentioned factors affects, in a negative and probably irremediable way, the quality of the urban territory we are dealing with.

4 Definition of strategies and their possible inclusion in the Master Plan

This area presents thermal conditions that are unfavourable for buildings and particularly for their users, both in housings and in the outer public space. It is, therefore, indispensable to optimize urban design, taking into account the local conditions, to ensure a higher energetic efficiency in buildings and to guarantee minimum quality levels for the use of the public space.

For this purpose, it is necessary, among other measures, to correctly distribute and orientate the buildings in such a manner as to avoid excessive shadowing over the neighbouring constructions and to allow the access of direct solar radiation. In this context, we can consider the following criterion: "*It is considered to have at least 4 hours of solar exposure during the day, in the most unfavourable day (winter solstice). At solar noon, there is the maximum solar altitude, for that it is considered sufficient to have solar incidence on the façades, at least between 10 a.m. and 14 p.m., solar time.*" [2]

The definition of this period of solar exposure is the starting point for the determination of the maximum angle that will define the relationship between the spacing and the height of the building immediately towards south and therefore causing possible shadowing (Fig. 3).

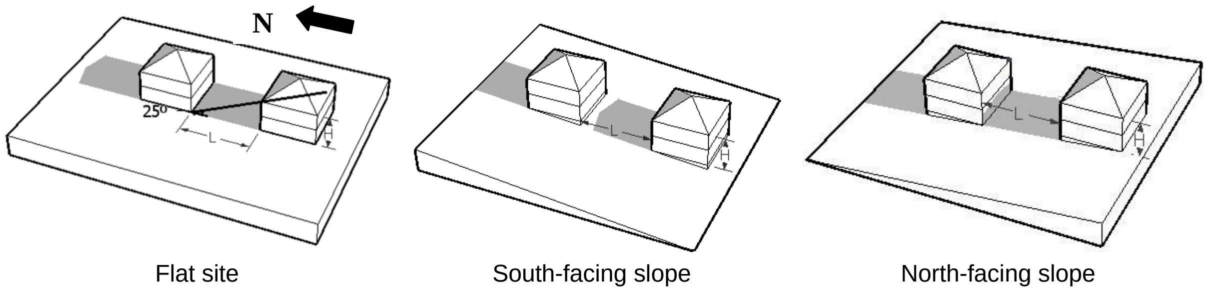

Figure 3: Angle for the determination of the ratio between buildings spacing and height (Winter solstice at solar noon)

For a latitude of about 41º N, the obstruction angle will have to be less than or equal to 25º [10], ensuring sun exposure directly in the South façades, throughout the whole year, according to the period of hours previously defined. The spacing between buildings and the respective height will still be corrected, as a function of the slope.

Apart from guaranteeing that each building or set of buildings has access to sunlight, one must consider, when outlining bioclimatic strategies for the territory, various other aspects, such as:

- The geometry of the sunlight (as regards, for example, the incidence of the sun in public spaces);
- The geomorphology (gradients on relief, exposure of the slopes, altitude);
- The characteristics of the urban space (existing or still to be projected);
- The influence of winds (wind flows, aeration, disposition/orientation of the streets and public spaces in relation to winds, cold areas and protected areas);
- The existence of vegetation and the distribution of green areas (buffer zones, conditions for thermal control, regeneration of oxygen, shade caused by vegetation);
- The hydrologic cycle (water cycle, hydric balance);
- The levels of comfort in the urban environment (characterization and definition of criteria).

Thus, the in-depth study of these aspects, that will be carried out, will create the necessary conditions for the definition of possible strategies that might be adopted in the Master Plan, as regulating actions for a better urban quality, following bioclimatic patterns. In a first approach, we can outline the following strategies:

A. Construction:

- Definition of maximum volumetry for buildings (from 1 to 4 floors), adequate to the streets' design, orientation and topography, thus allowing to attenuate the shadowing areas between buildings and in the streets [4];
- In the case of ground slopes higher than 5º, that characteristic should be included in the calculation of the relation between spacing and the buildings' heights;
- Definition of a maximum ground occupation density, coordinated with the definitions of volumetry and the street design that are defined;
- Definition of spacing according to the orientation of the streets, with a bigger spacing in streets that are E-W oriented than in streets that are N-S oriented;
- Definition of maximum height of gables and façades;
- Creation of covered circulation galleries in areas for commerce and services[5];
- Orientation of the construction volumes towards south in order to obtain the highest possible extension with direct solar light. The south orientation can be inflected up to 30º towards E or W;

- Definition of occupation typologies: multi-storey apartment buildings; detached, semi-detached or terraced single houses, making the bioclimatic guidelines compatible with the different densities established for the territory, choosing between the options of construction typologies included in the Master Plan [1];

B. Routes:

- Definition of new routes considering: orientation, topography, dimension and density of the surrounding constructions, maintaining the existing tree species and/or planting of new trees;
- Outline wider streets with an E – W orientation, in order to guarantee a full solar front for the buildings;
- Avoid the design of streets and paths that are too long in a straight line, choosing an alignment with some variation, preferentially uneven, curved and not rectilinear, thus attenuating possible wind corridors[6];
- On the intersection of E-W oriented streets with N-S oriented streets, there should always be evergreen trees, in order to absorb and reduce wind channels[8];
- Making crossroads off-centre and smaller, from 4 to 3 roads, in order to ease winds;
- The main or busiest roads should be N-S oriented (to facilitate traffic), and the E-W oriented streets should therefore have a less direct alignment (more curved), through the houses and local buildings;

C. Vegetation

- Preserve pockets of local vegetation, creating the necessary conditions for protecting green parks, allowing the control of humidity levels, soil permeability and protection of water lines, allowing only buildings in direct surroundings, with low density in terms of construction[7];
- Creation of spaces for public equipments with green areas, with low density and land occupancy, such as: sports ground on the open air, golf, tennis, volleyball, maintenance circuits, urban parks, etc. allowing the maintenance of green pockets in the territory;
- Guarantee lateral canals with trees in the routes;
- In the protection barriers from sea winds, there should be evergreen trees, preferentially stone pines, because of their large crown and small height. Deciduous tress should be used in areas near buildings, where there are important seasonal characteristics for their thermal optimization.

5 Final statements

In this paper, some reflections were presented which were carried out in a preliminary phase (one of diagnosis and definition) of a wider research project whose object is the northern part of the Portuguese coast and whose goal is the definition of specific bioclimatic strategies that should be included in the planning instruments for the region.

The goal of that work is, taking into account the constraints of the existing situation, to make:

- A geomorphologic analysis of all the constraints of the surrounding environment, particularly as regards topography, climate, vegetation and hydrography;
- A study of a proper coordination and re-organization of the urban spaces network, adjusting them to the local micro-climate;
- An analysis of the use of natural resources, organizing the territory accordingly, coordinating, re-organizing and orienting buildings and public spaces according to the climate;
- Presentation of planning proposals to define moderate construction densities and create the necessary conditions for mixed uses with diversified functions and activities;

- Proposals of structuring and coordination of roads, with new interventions on the search for solutions that are more adequate to the climate and to the topography;
- Definition of parameters as regards adequacy of construction, making the bioclimatic guidelines compatible with the different densities that are defined for the territory.

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