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The reality of spatial plans is delaying the growth of sustainable buildings

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Abstract

Urban planning aims to organize the change carried out in the territory. Urban planning is country policy in force by legislation and is materialized in spatial plans. All building construction has to comply with the models and regulation established in spatial plans.

The aim of this study was to realize if spatial plans are using regulations and space occupancy models that promote energy and water conservation in buildings. The study starts with a brief approach to main design principals, which have to be addressed to achieve energy and water conservation in buildings. After that, a survey, in 20 spatial plans for 7 different Portuguese cities, was conducted in order to find out how many of these features are implemented in the plans.

It was concluded that the rules set by the spatial plans reviewed, do not intent energy or water conservation in buildings. Communally the rules are based on urban and building quantification. It is important to realize that this type of regulations are out dated and do not promote sustainable buildings.

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Keywords: Detailed plan; Municipal master plan; Urban planning; Spatial plans; Sustainable urban planning; Sustainable buildings; Water and energy conservation

1. Introduction

Urban planning is simultaneously a science and an art that aims to manage and optimize the inevitable change done by men in the territory, ensuring heritage and natural preservation, while minimizing the impact on the environment. Initially, the main concern in planning was the land use, building development and infrastructure [1]. Today urban planning is about the regulation of urbanization, considering economic, social and environment aspects important for human life. By definition, urban planning anticipates the future needs [2] of cities and settlements, and tries to prevent damages in the territory. Urban planning is a government responsibility, therefore, regulated by legislation. In Europe, all countries have legislation and a policy for land use and territory occupancy.

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Nomenclature

DP	Detailed plan
MMP	Municipal master plan

A spatial plan concretizes and materializes each country policy for urban planning. Spatial plans are particularly important as they represent a window to the future city. All building construction, refurbishment or retrofitting and landscape or infrastructures have to comply with rules and models present in spatial plans. Spatial plans are issued and enforced by the authorities.

So that buildings and cities are sustainable in the future, cities must have spatial plans with rules and models that promote sustainable construction now. This means that spatial plans have to take into consideration the features that improve energy efficiency and water conservation in buildings. Strategies for sustainable building construction can be found in an extended range of literature. However, few consider site planning and none were found regarding the actual exiting plans. This paper comprises an overview of all the fundamental features, both in buildings and in site layout to achieve energy and water conservation in buildings. After that, a survey on spatial plans targeted at fastening these characteristics is presented.

2. Energy efficiency and water conservation in buildings

Today, it is widely accepted that buildings should consume less energy and less water. In part because buildings represent around 40% of energy consumption [3] and only 0.3% of the water is available for human consumption [4], in part because world population may achieve 9 billion in a few decades [5] and earth resources are limited. In Europe the goal is nearly zero-energy buildings. These buildings involve simultaneously very low energy consumption and renewable energy production meeting that the building's needs.

2.1. Low energy buildings

To achieve low energy consumption in buildings without compromising comfort and health three aspects should be addressed: building surrounding, building features, and occupants' behavior.

Building surrounding determines the conditions in which the building operates. The conditions such as air temperature, solar access and wind in an urban environment depend on the local climate as well as on the urban fabric that creates a microclimate [6]. The urban fabric includes the buildings and the space in-between, such as roads and gardens. The main urban fabric characteristics that impact on building conditions are [7]:

- The road network because it affects the building layout. Usually buildings are laid out facing the road, but to be able to implement solar and energy saving techniques it is fundamental that the building has a facade facing south. Having a facade with windows facing south is essential for passive solar heating.
- The relationship between buildings height and road width. In urban environment, buildings may obstruct one another the sunlight one another. Narrow roads with high buildings prevent sun penetration and daylight.
- Green areas with vegetation and trees. Vegetation improves climatic conditions, helps to moderate microclimate, and avoids extreme temperatures. Trees may provide shading in summer and wind-breaks in winter.

Building features are needed to provide occupant comfort and include passive and active technologies. Active technologies, such as heaters and air conditioners, are commonly used to condition indoor temperature and moisture. All active technologies spend energy, therefore they should be energy-efficient. Passive technologies in a building may improve comfort significantly, without energy consumption. The basic ones are:

- Internal spaces arrangement. Spaces such as living rooms, offices and bedrooms where comfort is expected and occupants spend long periods of time should be south oriented. Storage spaces, hallways and corridors may be on the north side of the building.

- External walls should have thermal insulation. Thermal insulation keeps solar gains and prevents temperate loss in the winter. Thermal insulation should be placed externally in massive walls to keep building thermal inertia, which is the main factor to avoid day time heating in summer. To prevent over heating in summer, facades should be finished in light colors.
- Windows and shading devices. Windows allow the building to have solar gains but represent a weakness in thermal loss in winter. Windows may also be responsible for overheating in summer. Windows should have enough thermal insulation but still allow solar gains in general, which requires a combination in glazing materials normally achieved with double glazing. Windows should also have shading devices to prevent overheating in summer.
- Ventilation. Ventilation is crucial to have a clean air environment, but it is also a way to lose heat in the winter. Ventilation rates should be kept all year, according to the building use. In mild climates, natural ventilation techniques are preferable. A heat recovery should be used in cold climates. In hot climates a heat dissipation technique using water or ground soil could be advisable.

Occupants play an important role as they use both passive and active systems. Occupants must know the importance of opening the shutters to receive sun and light in the winter and to use the shadow devices to prevent overheating in summer. Occupants should not set the heating system for high temperatures in winter, nor the, air conditioner for very low temperatures in summer. Occupants should know how and when to ventilate to take the most from the outside temperature.

This section introduced a sum up of the basic strategies that should be present in buildings. Applying these basic concepts enables the construction of very low energy consumption buildings without compromising comfort and the occupants' health. This overview was important to realize that a significant part of these strategies lies on the building layout and on the soundings.

2.2. *Water efficiency and conservation in building*

Water efficiency refers to all the efforts that lead to reduce water consumption and wastage. This helps to reduce wastewater and to save water resources [8]. Buildings may achieve low water consumption by using efficient fittings, recycling greywater, and by using rain water.

The use of efficient fittings, such as low flow taps, low consumption washing machines, and leak detection will reduce water usage in a building.

Graywater recycling reduces water consumption and wastewater production. Greywater is all wastewater from the household excluding dishwashers, kitchen sinks, and toilets. Reuse greywater, from showers, bathtubs, and washing machines for non-potable purposes, such as, toilets and urinals flushing. Greywater reuse may represent 1/3 of reduction in water consumption in a building [9].

Rain water usage reduces water consumption. Harvesting rain water to be used in toilets, exterior and car washing, and also in irrigation. This is another way to reduce water consumption.

This summarizes the basic strategies to consider in buildings to achieve water conservation.

2.3. *Plans contribution*

Plans have a significant contribution in building surroundings design, and building layout. To improve energy and water efficiency, plans must include regulations concerning:

- Building layout. It is important that the buildings' facades are disassociated from streets orientation. Besides, all buildings must have one facade with windows, preferably the largest, facing south quadrant. If necessary, building alignment may be discontinued. To choose building best site, all plot should be consider, not only the street front.
- Buildings height. Always relate buildings height with the space between buildings. To have sun penetration all year, solar altitude in winter solstice has to be considered, both for building spacing and height.
- Green areas and trees. Occupancy models should set a land proportion for green areas. At least small green areas between the buildings should be considered. Moreover, the creation of windbreaks and sun shading with trees along the streets is advisable.

- Rain water harvesting. Plans should consider setting a system to collect, storage and supply rain water. Preferably each building should have an independent system. However, a collective tank may be needed to supply buildings in small plots.

The applications of these principles, in spatial plans, generate conditions for the appearance of sustainable buildings. These principals are simple but will make a difference.

3. How plans really regulate construction

Portuguese legislation establishes different types of spatial plans. The present study focused on the municipal master plan and on the detailed plan. The Municipal master plan (MMP) defines the main strategy for municipal territory and the occupation model. MMPs are mandatory and each municipality has one covering the complete territory. The Detailed plan (DP) covers a part of the municipality territory. Its main objective is to develop and implement the occupancy models set by the MMP. The DP defines buildings volume and layout, roads and the spaces that shape the urban environment.

To understand how construction has been regulated, a survey was conducted. This survey analyzed plans used in seven different Portuguese municipalities, totalizing twenty different spatial plans. The survey included seven MMP and thirteen DP, as shown in Table 1. The selected municipalities were chosen for the importance of their cities and also due to their inhabitants' number.

Table 1. Population, MMP and DP legal documents per municipality.

Municipality:	Population:	MMP document:	DP document:
Almada	173 298	RCM 5/1997 + RCM 100/98 + Edital 511/2017 + Aviso nº 15415/2017	Edital nº 781/2013 Edital nº 1088/2016
Amadora	175 558	RCM 44/94 + Decl 3/2001 + Decl 312/2002 + Decl 85/2003 + Decl 64/2004 + RCM 12/2004 + Decl 78/2006 + Aviso 1299/2017 + Aviso 14755/2017 + Aviso 7056/2018	Edital nº 1/2010 Aviso nº 8244/2009
Coimbra	143 052	Aviso nº 8289/2017 + Aviso 7635/2014	Aviso nº 16075/2012 Aviso nº 25194/2010
Lisboa	545 245	Aviso 11622/2012 + Aviso 5804/2014 + Decl 687/2015 + Decl 68/2015 + Aviso 2099/2017 + Aviso 9444/2017 + Decl 13/2018	Aviso nº 10052/2011 Aviso nº 19314/2018
Matosinhos	174 931	Desp 92/92 + Decl 334/2001 + RCM 10/2002 + Aviso 3139/2014 + Aviso 1870/2017	Aviso nº 513/2015 Aviso nº 3238/2017
Porto	237 559	RCM 19/2006 + Aviso 4272/2012 + Aviso 1433/2012 + Aviso 8094/2014 + Aviso 11352/2015 + Aviso 8637/2017	Aviso nº 11535/2014 Decl Ret nº 824/2017
Vila Nova Gaia	302 092	Aviso 14327 + Aviso 904/2013 + Aviso 980/2018 + Aviso 9505/2018	Decl 29 − 1 − 92

In all municipalities the MMP initial version had been altered, over the years. That is the reason why several documents had to be consulted for the MMP. For each municipality, two DP were chosen from the plans in force, except for Vila Nova Gaia, which only had one DP.

3.1. Municipal master plans

The survey carried out in MMP showed that all MMPs organize the territory dividing it into zones (Table 2). It was also shown that all MMP regulate building construction by limiting the construction area. For that the MMP use plot ratio, which is the ratio from the total floor area of a development to its site area [10]. Two MMPs combine the limitation in construction area with the limitation on the building footprint. The ratio of the building footprint to its site area is site coverage [10]. Five MMPs combine the construction area with maximum floor number.

Table 2. Regulated aspects in MMP.

Municipality:	Zones	Plot ratio	Site coverage	Max floor number	Building layout	Green areas
Almada	Yes	Yes	Yes	Yes	No	Yes
Amadora	Yes	Yes	No	Yes	No	Yes
Coimbra	Yes	Yes	No	Yes	No	Yes
Lisboa	Yes	Yes	Yes	Yes	No	Yes
Matosinhos	Yes	Yes	No	No	No	Yes
Porto	Yes	Yes	No	No	No	Yes
Vila Nova Gaia	Yes	Yes	No	Yes	No	Yes

The survey also looked for rules that guide building layout and, as shown in Table 2, none of the MMPs had. All MMPs had rules for green areas but these rules are set to protect exiting parks.

This survey also showed that the plot ratio values used in MMP vary between 0.3 and 1.8 (Fig. 1). All MMPs, except Matosinhos, use different plot ratio values according to the zone. The values used may be considered low.

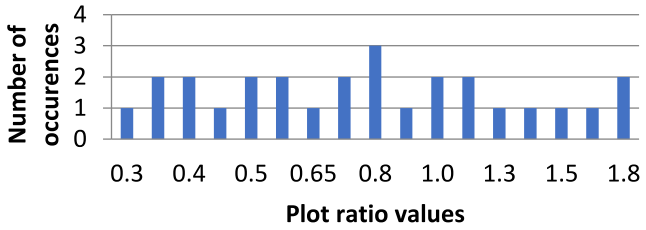

Fig. 1. Distribution of plot ratio values per occurrences.

It was also possible to analyze that maximum floor number used in MMP varies between 2 and 8 (Fig. 2). The MMPs use different values for different zones. The most used values are from 2 to 5, which may be considered moderate.

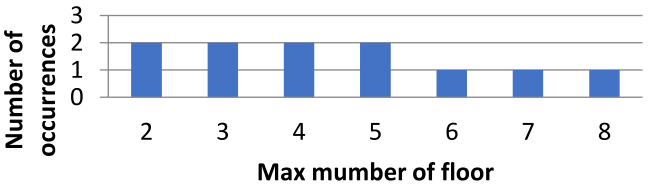

Fig. 2. Distribution of max number of floor per occurrences.

This survey showed that the main strategy in MMP is to limit construction and protect green areas. No other rules or suggestions were found in these MMPs.

3.2. Detail plans

A detail plan (DP) defines buildings layout and urban space arrangement. The survey on DP aimed to find out if the buildings solution had included features that enable buildings to be energy and water efficient. The result of the survey is presented in Table 3.

The features looked on in the DP were if buildings have south facing facades and whether sun penetration was assured. The result showed that, although more than half have at least a part of the facades facing south, only one DP assured enough spacing for sun penetration. The other features looked for were if green areas were settled in the space around buildings. The survey showed that all DPs consider some green landscape. The last feature looked on was the possibility for rain water harvesting and reuse. The survey showed that none of the DPs had this feature.

Table 3. Design features presented in DP.

Municipality:	Location:	South facing facades	Sun penetration	Green spaces	Rain water harvesting
Almada	Cacilhas	Part (<50%)	Part	Yes	No
	Caparica	Part (<50%)	No	Yes	Yes, but not to reuse
Amadora	S. Bras	Yes (>50%)	Yes	Yes	No
	Elias Garcia	Part (<50%)	No	Yes	No
Coimbra	P Tecnológico	Part (<50%)	No	Yes	No
	Taveiro	No	No	Yes	No
Lisboa	Amoreiras	Part (<50%)	No	Yes	No
	Casal Pinto	No	No	Yes	No
Matosinhos	S Zenha	No	No	Yes	No
	G Guerra	Part (<50%)	No	No	No
Porto	Antas	Part (<50%)	No	Yes	No
	Dallas	No	No	No	No
Vila Nova Gaia	P Concelho	No	No	No	No

4. Conclusions

Although the importance of sustainable construction is widely accepted, somehow Portuguese cities have few sustainable buildings. Even those buildings that have been recently finished miss to achieve high standards in energy and water conservation.

The survey carried out on 20 different spatial plans revealed that the main concern is construction limitation. All plans had at least one ratio to determine the maximum construction area allowed for the plot area. The values set in the MMP for limiting construction area and floor number are acceptable for encouraging buildings into passive solar technologies, mainly because the values are considered low. The main issue is that these values do not consider other aspects, such as layout, south orientation and sun penetration. Low values are not enough to guarantee solar technologies effectiveness. This way, the MMPs do not disable sustainable building measures, but they do but do not encourage them as well. It was also possible to realize that DPs do not organize urban space, nor do building layout based on sustainable principles. The main reason is because the DP executes the MMP policies. Since MMPs do not have policies promoting sustainable building features, DPs do not have them either.

It is important to realize that with this kind of regulations the number of sustainable buildings in the future will continue to be low. Spatial planning has to be urgently changed so that future construction can be improved.

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