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Balint Halasz

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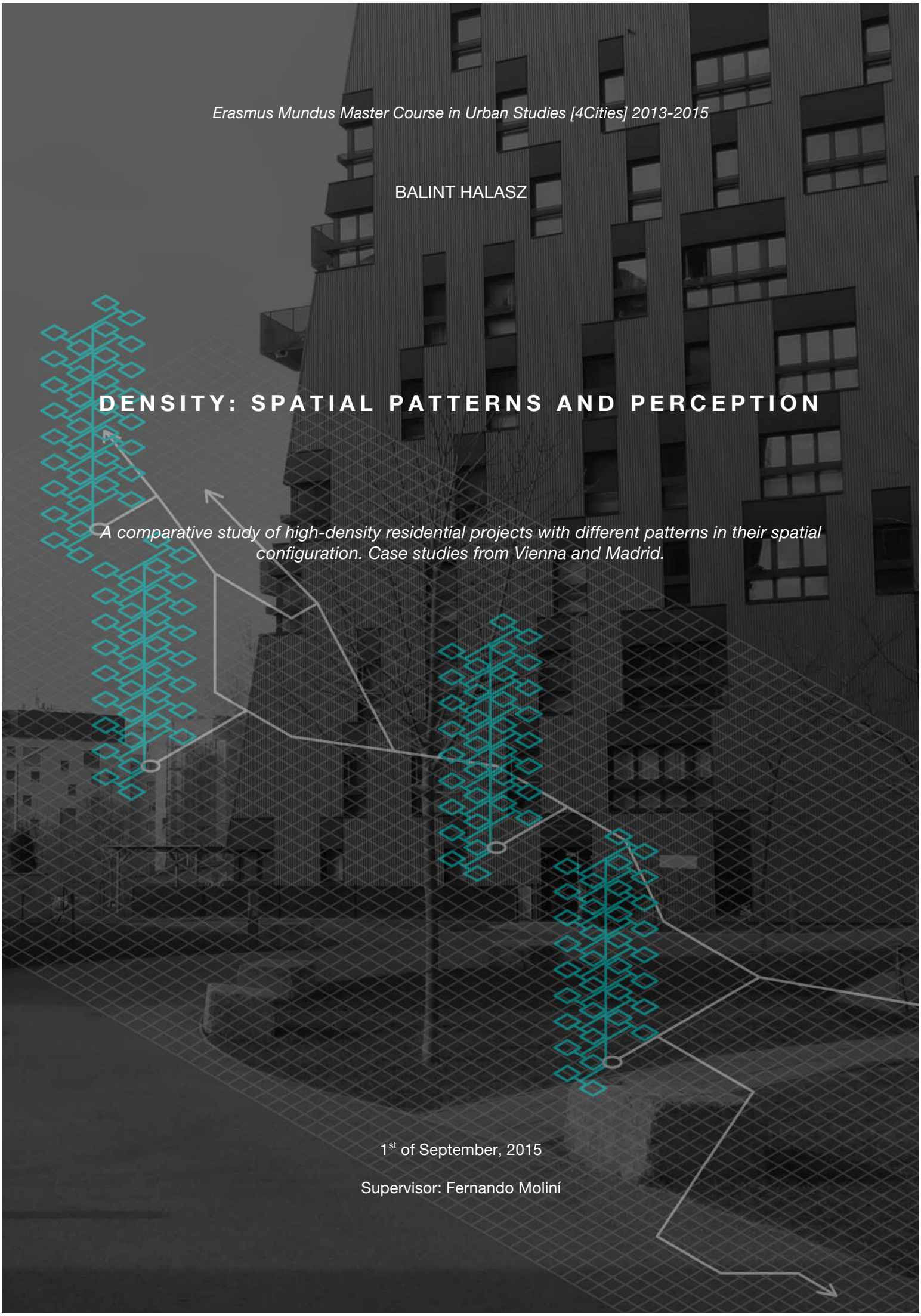

Erasmus Mundus Master Course in Urban Studies [4Cities] 2013-2015

BALINT HALASZ

DENSITY: SPATIAL PATTERNS AND PERCEPTION

A comparative study of high-density residential projects with different patterns in their spatial configuration. Case studies from Vienna and Madrid.

1st of September, 2015

Supervisor: Fernando Moliní

“A society does more than simply exist in space. It also takes on a definite spatial form and in that it does in two senses. First, is arranges people in space that it locates them in relation to each other, with a greater or lesser degree of aggregation and separation, engendering patterns of movement and encounter that may be dense or sparse within or between different groupings. Second, it arranges space itself by means of buildings, boundaries, paths, markers, zones, and so on, so that the physical milieu of that society also takes on a definite pattern. In both senses a society acquires definite and recognizable spatial order.”

(Hillier and Hanson, 1984)

ABSTRACT

Similar overall urban densities can be achieved with very different spatial layouts, potentially providing very different user experiences. The thesis investigates the interrelations between building density (objective densities and their distribution), spatial configuration (connectivity and visibility) and the experience of urban density (subjective density). The scope of the research is the urban block, by comparing residential projects from Madrid and Vienna with different patterns in their spatial layouts, but similarly high dwelling density. The results show strong interdependencies between density distribution and spatial configuration. The experience of density is linked to certain variables of the spatial layout, though the connection is rather weak.

KURZZUSAMMENFASSUNG

Ähnliche städtische Dichte kann mit sehr unterschiedlichen räumlichen Anordnungen erreicht werden und dabei für sehr unterschiedliche Wahrnehmungen bei den Nutzern sorgen. Diese Arbeit untersucht die Zusammenhänge zwischen Gebäudedichte (objektive Dichte und Verteilung), räumliche Struktur (Verbindung und Visualisierung) und Wahrnehmung von städtischer Dichte (subjective Dichte). Der Rahmen dieser Arbeit ist der Stadtblock, dabei werden Wohnprojekte aus Madrid und Wien mit unterschiedlichen räumlichen Strukturen, aber ähnlich hoher Dichte verglichen. Die Resultate zeigen, dass es starke Zusammenhänge zwischen Dichteverteilung und der räumlichen Struktur gibt. Die Wahrnehmung von Dichte hängt mit bestimmten Variablen der räumlichen Anordnung zusammen, diese Verbindung ist jedoch nur schwach ausgeprägt.

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1. INTRODUCTION

> *"The proportionately high development density expresses the concentration of urban life, satisfying the legitimate claim to urbanity, experiential value, intimacy and attractiveness. Density is the city's third dimension. Density is a critical tool, linked as much to the dimensions and disposition of the urban plan as to the traffic flows evoked by the untold relations between the parts of the city. By processing density, the city is shaped in plan and section and its areas and individual buildings fixed"*
>
> *(The Metapolis Dictionary of Advanced Architecture, 2000)*

As the quote above suggests, density is a determinant quality of urbanity, crucial to understand by research, in order to potentially influence processes of aggregation and dispersion in the city through planning. Density is not simply the intensity of the built or the population and the disposition of this intensity, but it's also closely linked to the relational qualities between components of the city, that is defining movements of people, information and goods between the different functional units. Therefore density should be examined along with the configurational aspects of urban space.

The thesis focuses on the implications of urban density in relation with spatial organization, on the scale of architecture. To show the high relevance to the topic, the theme of density is looked at in the context of the densification objectives set by current planning policies. The relationship between density and architecture is twofold: on one hand density is a major defining factor of architecture, on the other hand architectural configuration has an influence on several measures of density. Architecture is the technical and symbolic instrument in projecting planning policies, operations of land markets, social and property relationships and patterns of personal and cultural behavior into spatial structures (Cuthbert, 1985), spatial configuration being its primary focus and tool. In this sense, a major goal of the architectural design process is adapting space to density targets of various qualities ascertained beforehand. Inversely, architecture by defining the structure of the built environment has an influence on the perception of density and the intensity of the usage of space, potentially reducing the negative externalities of both high and low density and enhancing the positive ones. The relationship between society and space is closely linked to the theme of density, which can be approached on various scales and both in terms of social and spatial density. High spatial density increases "both the frequency and intensity of group interaction" as the distance between people affects their ability to communicate (Cuthbert, 1985), higher physical density raises the level of "interpersonal and inter-institutional accessibility and, at the same time, the probability of interaction" (Hawley, 1972), having implications on social density. This thesis tries to reflect on the relation of spatial density and the quality of social interactions.

The measurement of density poses several challenges, as its definition is varying by discipline and incorporated in planning depending on the differing historical, political, social, economical, technological and ecological contexts (Churchman, 1999). There is no consensus on issues of measurement density being a quantitative, objective concept and a qualitative, subjective concept at the same time. There is a lack of international standards in the definition of low, medium and high density (Sivam et al., 2011), furthermore a debate is going on about the appropriate measures (Churchman, 1999) representing more on one hand the socio-

economic context, on the other quality of inhabiting the urban environment rather than one-dimensional, neutral, static measures, and helping assess the impact of densification on the everyday life of the inhabitants. Objective measures of density may be defined by people, dwellings, jobs, networks, etc., representing average numbers that might significantly differ if the scale on what is measured is changed. Perceived density is one of the subjective measures this thesis focuses on, defined by Churchman (1999) as an *"individual's (…) estimate of the number of cues in the environment that represent people and their activities",* with perceptual, associational-symbolic, temporal and physical contributing factors – that may significantly differ to the objective measures listed above.

The measurement of spatial density is ambiguous, not only for the controversies in the definitions and metrics of density but also of space. Space is quantifiable and qualitative at the same time, it can be described according to its objective properties, and also according to the subjective experience of it. Hillier (1984) is defining space through its configuration. To do that, he identifies components of space and examines the relationship between these components (describing quantitative measures), identifying spatial configuration as a factor influencing different aspects of social and spatial density. Therefore, spatial organization (closely linked to density) is in the scope of thesis, analyzing configurational characteristics (involving selected quantitative factors) of residential projects that are targeting similar objective overall density measures. With such an analysis different spatial patterns may be identified, that can be compared in terms of intensity of usage and the inhabitants' subjective experience of density.

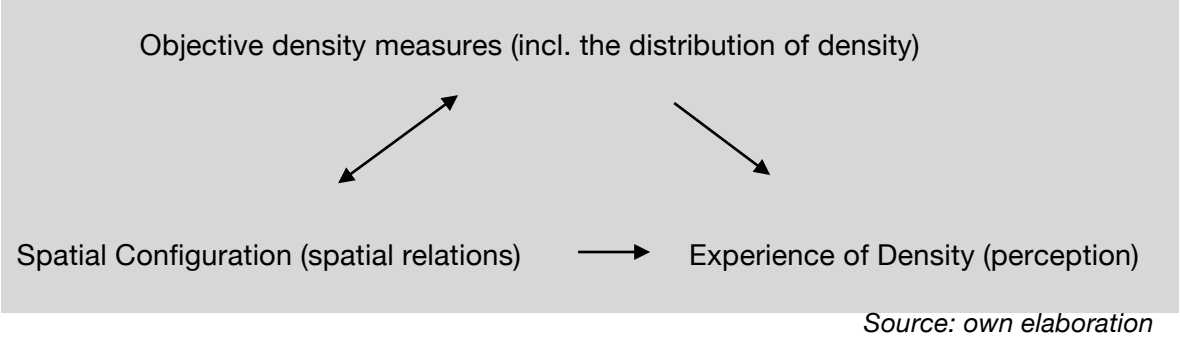
The scope in what the relation of density and spatial configuration may be investigated is extremely wide, therefore came up the need to narrow down the examined implications. The thesis focuses on those aspects of density and spatial configuration that are related to user satisfaction with the residential physical environment. The densification objectives often set by current planning policies may be undermined by the low acceptability of high-density urban environments for dwelling. Residential satisfaction and locational choices are a major factor influencing macro-scale processes defining how dense our cities are overall - when looking at the experience of density, those factors of the built environment are examined that are linked to user satisfaction. By understanding processes on the scale of architecture, there may be a chance to give a new insight to the debates about density targets on other scales in planning as well.

To sum up, the focus of the research is how the spatial problem of density is unfolding on the scale of the urban block. The thesis is divided in two sections: the first incorporates the theorization of density and spatial configuration, and attempts to set up a link between them. Furthermore, this section gives an overview on the approaches to ideal density and finally tries to map those factors of the physical environment that are relevant in preferences for a certain density or spatial layout. The second section involves the description of the case studies, the methodology, provides the results and attempts to draw a conclusion.

2. FOCUS OF THE THESIS AND RESEARCH QUESTIONS

2.1. RESEARCH QUESTIONS

The thesis focuses on the spatial layout of high-density residential projects. This layout has implications on (1) the distribution of the actual overall densities (combinatory aspects of the layout), and on (2) spatial configuration (relational aspects of the layout). In the end, spatial distribution and relations both have an effect on the experience of density by the user.



Source: own elaboration

The research explores, on one hand, the relation between the distribution of densities, which also implies a certain "form of the arrangements of people in space" (Rapoport, 1975), and its perception by the users. The thesis wishes to take a comprehensive approach in evaluating spatial configurations in terms of perception, and combine factors of various qualities, which are all related to both the usage of space and density.

Research questions:

1. What are the effects of high density in the usage and perception of urban space?

2. How do the effects vary depending on the patterns in its spatial layout?

3. Is there a discrepancy between objective measures of density and the subjective perceived density?

4. Is it possible to find and refine methodological tools to measure spatial qualities that are influencing how the users experience density?

Components of the research questions:
a) Effects: advantages and disadvantages related to and derived from high residential density;
b) High density in this research is a number of dwellings per hectare over 120.
c) Urban space: usage of both public and private space (objective measures) and perception of the urban environment (subjective measures).
d) Patterns in the spatial layout: easily distinguishable spatial layouts with different measures of connectivity and inter-visibility, which range from low to high-rise layouts;
e) Objective measure of density: dwellings per hectare, floor area ratio, ratio of open space, etc.
f) Perceived density: perception of selected properties of the environment and of the relation between users;

A GRAPHICAL REPRESENTATION OF THE PROBLEM

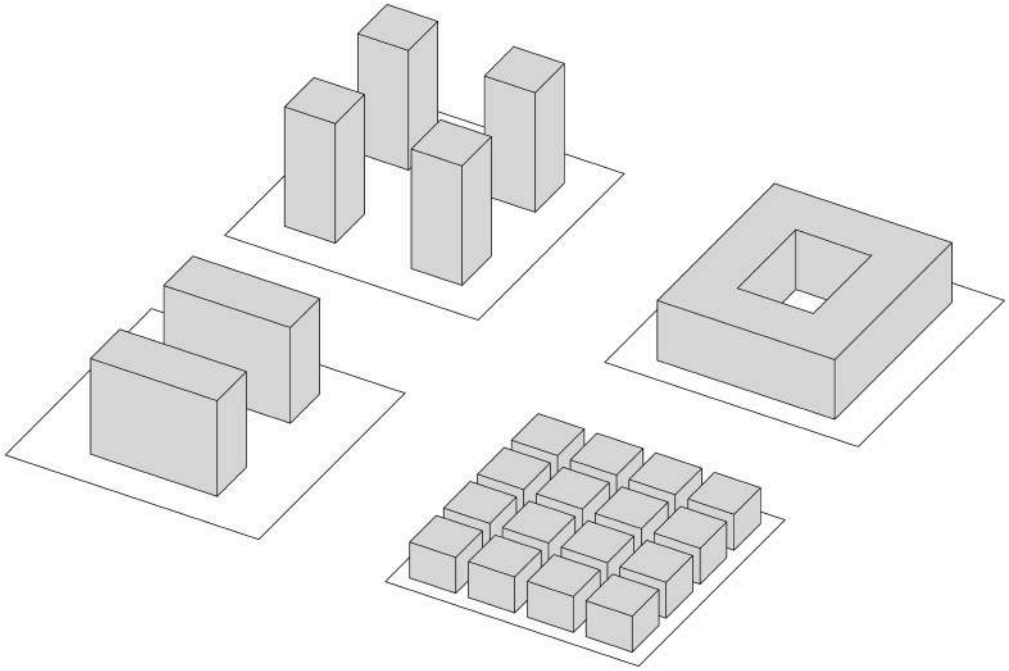


Figure 1.: Four urban typologies with the same overall density but different distribution of density, from high to low rise (the site area in all cases is 100 square units, the total floor area is 160 square units, but this equal floor area ratio is obtained with different building heights of 10, 8, 5 and 3 floors), source: own elaboration

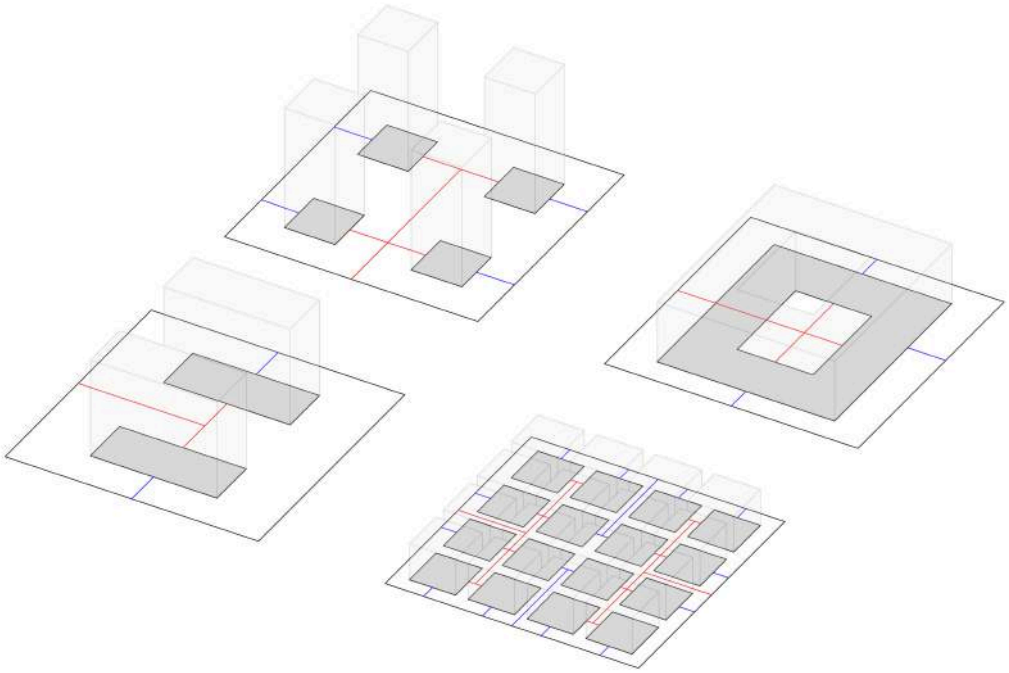


Figure 2.: Two typologies in the spatial relation between the volumes (red: connected units, blue: non connected units), source: own elaboration

2.2. EXPECTED RESULTS

The result of the research would be the assessment of residential projects with high objective densities and with different spatial configurations, focusing on the subjective experience of density. The expected results would point out differences in the perception of density, depending on the design strategies taken to configure space, and mapping the disparities between the actual objective density measures and the subjective ones. The thesis has preliminary assumptions about the relation of objective density, spatial layout and the experience of density, based on the distinction between typologies ranging from low to high-rise projects. Low and high rise projects inherently operate with different distribution of density and spatial configurations: the former are in general patio houses or courtyard blocks, characterized with a high ratio of space covered with buildings, while high rises are free standing bars or point houses, characterized with a lower ratio of built area. The typologies are distinctive in their circulation system as well, resulting in different connectivity and visibility patterns. The case studies are chosen based on this distinction.

The thesis presupposes that the users of lower rise typologies experience density higher than those of free standing blocks, as (1.) Privacy is perceived lower in courtyard and patio layouts, (2.) Interaction with the neighbors is higher in low-rise typologies, due to the specific permeability patterns (3.) Access to sunshine, green, good ventilation therefore the perception of healthiness of their environment is considered worse among the inhabitants of low-rise typologies, (4.) Low-rise projects have lower visibility which implies higher perceived density.

During the design process, only some specific aspects of urban density (or factors influencing density) are controlled consciously (floor area ratio, building height, the number of dwellings per hectare). Other factors are controlled indirectly, let alone influenced by different kinds of visions of the designers. The actual, objective measures of densities realized therefore may match the anticipated usages and perceived densities only in some aspects. The different experience of space influences the attractiveness of the project, the acceptability of high density and may have an impact on the locational preference of the users. A preferable result of the thesis would be if certain aspects of the different spatial configurations could be identified that are relevant in the perception of density. Also, a preferable outcome would be if a generalizable method could be set up to describe density beyond the well-known measures, that tells more about what distribution of density is possible and what kind of spatial configuration has to be applied for that. The research tries to widen the understanding of density on a micro-scale to contribute to design knowledge, to draw up suggestions for a more adequate regulatory context for construction more sensitive to the experience of density, and if possible, to formulate critiques of macro-scale densification policies.

3. THEORETICAL BACKGROUND

3.1. APPROACHES TO DENSITY

Different theorizations and approaches to density result in different concepts of an 'ideal density', that may be defined as a balance between the negative and positive externalities of spatial or social density. The following overview attempts to give a rather comprehensive picture of different considerations leading to different density targets - later translated in planning policies (strategic plans) and regulations (construction laws), in the end giving a frame in what architectural design operates. Macro scale considerations are unfolded by looking at the on-going compact city debate, while micro scale approaches are examined through the lens of environmental behavior studies, focusing on the role of the individual's perception.

Macro theories understanding density as a result of social production may approach urban density from a neo-Marxist or a neo-classical perspective (Cuthbert, 1985). The neo-Marxist models assume that the mode of production is the determinant of human actions, and exploring the relationship between spatial configuration of the build environment (e.g. geographical concentration or dispersal, shape and form of the urban system) and the circulation of capital (e.g. consumption and production, concentration of economic surplus) (Harvey, 1985). Neo-classical models on the other hand are explaining urban processes as a result of individual choices made by households or firms (Alonso, 1964, Muth 1969). Models of residential location - and related to that of density -, is explained through the relation of travel times, housing costs, lifestyle choices or other individual preferences (Cuthbert, 1985). The distinction between these two models may give a wider interpretation framework for the considerations presented below. Micro scale approaches that are in the focus of this thesis are centered on the role of cognitive processes in evaluating space, that may be viewed as a third theoretical framework in interpreting density related issues.

3.1.1. Macro-scale approaches to density – the compact city debate

Macro level approaches to urban density are focusing on urban systems, land uses, economic, political and institutional frameworks, and debates about an 'ideal density' are closely related to the preferable compactness of the city. The controversy centered on sprawl versus compact city is a current debate without any consensus reached. Definitions of compactness and sprawl are differing in different contexts, and indicators for measuring them may also be very diverse. Nevertheless, different measures of urban density are commonly used as an indicator. For instance, - beside efficiency of land use, variety of housing form, efficiency of infrastructure provision, mixed land use, car use and commuting distances, housing affordability, quality of life - Alexander and Tomalty (2002) uses population density to determine compaction. Burton (1999) points out that in general compaction is associated with high density, mixed uses, an urban layout that is encouraging walking and cycling and allows an efficient public transit system, while sprawl with the contrary. Some of the density measures Burton uses are - among others - gross densities of households, people in built-up areas, residential built-up areas, population weighted density measures, density of sub-centers, housing density and the increases in different densities. The diversity of the possible indicators is showing the variety of methods to measure compactness or dispersion, potentially ending in different results. According to Burton, compactness can be achieved with densification beside intensification and consolidation, involving a more intensive use of urban buildings, brown field developments, the conversion of existing developments and re-urbanization. This also

highlights the complexity of the solutions and related policies and planning tools to reach compaction objectives. Nevertheless, density is a major indicator of compactness and densification is a major tool to create compact cities. OECD (2012) defines compaction as achieving high density measures within the limits of an urban area, in the present thesis compact city is defined by dense and proximate development patterns[1].

3.1.1.1. Pro-compaction arguments

Advocates of the compact city emphasize compaction's benefits in terms of sustainability affecting all three pillars of it, the economic, the social and the environmental one.

Certain authors are in favor of high density and compact development, linking urban form with measures of environmental sustainability (Jenks, 2000). Alexander and Tomalty (2002) identify efficient land use, less pressure on natural habitats, reduced consumption of energy and water as environmental benefits. Molini and Salgado (2012) mention as an environmental advantage - among others - the reduced consumption of private and public undeveloped land, the preservation of rural areas with ecological values, furthermore reduced energy, water and non-renewable consumption. Dieleman et al. (2001) identifies density as a factor reducing car use therefore resulting in lower CO_2 emissions. Compact city policies are targeting to reduce intra-urban trip distances, save land for agriculture, recreation and water provision, contributing to maintain biodiversity (OECD,2012).

Some researches point out the potential economic benefits of compaction, such as the more cost-efficient operation of urban services, infrastructures and other benefits on public finance through local government spending (Carruthers and Ulfarsson, 2008, OECD, 2012). Carruthers et al. argues that efficiency in public spending may give a comparative advantage to places pursuing smart growth and anti-sprawl policies. Further economic benefit may be increased "productivity due to more diversity, vitality, innovation and creativity" (OECD, 2012), furthermore decreased commuting costs improving the way the labor market operates (OECD, 2012). Alexander and Tomalty (2002) also mentions as *economic benefits* the economically more viable public transit and provision and use of infrastructure (sewage facilities, less street coverage, less land dedicated to roads) more efficient and more mixed land use beneficial for some businesses due to the provision of a greater clientele and employee base, furthermore a better balance in the jobs and labor force ratios. Reduced car use and commuting distances have both environmental and economic benefits, even though according to Alexander and Tomalty certain low-density communities without any major adjacent centers show short commuting distances as well. Sassen (2001) emphasizes the advantages of agglomeration economies in relation with high urban concentration and the possibility of economies of scale. Nevertheless, the complexity of the issue and the variety of factors makes extremely hard to draw a balance, as Molini and Salgado (2012) points out: *"most theoretical perspectives are not able to determine the importance of the compact city or the sprawl. For example, in the role of agglomeration economies in urban growth, it is not clear whether the compact or the dispersed city plays a different role."*

Others identify certain social benefits derived from high density environment: Jacobs (1961) and Katz (1994) point out that compact planning may be more oriented towards community. High density may also be a factor limiting segregation (Couch, Kachera, 2006), even though Burton argues that there are both positive and negative consequences of urban compaction in terms of social equity (Burton, 1999). She identifies different indicators[2] that are

[1] OECD identifies three key characteristics of a compact city, which are "dense and proximate development patterns, urban areas

[2] The indicators used in the research are accessibility of facilities, access to green space, job accessibility, the quality of public transit, opportunities for non-motorized transportation, the amount of domestic living space, health indicators, crime levels, levels of social segregation and the availability of affordable housing.

linked both to social justice and urban form in order to determine if compactness favors social equity, which is related to access to certain social or primary goods and a relative equality of conditions. Burton finds that in some cases compactness is favorable in terms of social equity (transit, social segregation, accessibility of facilities), whereas other variables (domestic living space, affordable housing, crime, non-motorized transport) the contrary can be said. Hawley (1972) highlights other benefits of high density, such as involuntary exposure to education, cosmopolitanism and innovative ideas. Alexander and Tomalty (2002) mentions the improvement of life quality in the compact city for certain social groups, a variety of housing types and the affordability of smaller units resulting in a wider range in the choice for housing. According to Alexander and Tomalty, affordability is inversely related to density, though poorer people tend to move to higher density areas due to the better accessibility of facilities and social services and lower transportation costs - though this relation is context dependent. Another social aspect of compactness is in relation with security. Certain authors are associating compactness with lower crime rates or suggesting that low density can lead to higher crime figures. According to Jacobs (1961), dense urban conditions are enabling 'eyes on the street' limiting potential wrongdoing. According to Elkin et al. (1991) the compact city, through the pedestrian oriented public spaces promotes personal safety. Other authors found that detached houses are more likely to be a target of burglary (Winchester and Jackson, 1982).

Further identified benefits of urban compaction are positive effects on individual's health due to a shift from motorized to active transport (OECD, 2012), on the other hand DeGuzman et al. (2013) does not find significant relationship between walkability and health conditions of the population, pointing out the importance of socio-economic factors rather than urban form.

3.1.1.2. Anti–compaction arguments

Contrasting the benefits of compaction, some are pointing out the negative environmental effects of high density. Nicholson-Lord (1987) identifies as a major drawback the insufficient access to nature, advocating for dispersed urban patterns, which provide more private green space. Low-density residential environment also may be more advantageous layouts in terms of views, light and ventilation (Molini and Salgado, 2012). As Neuman (2004) points out in relation with the historical dense urban patterns, there is an *"accumulated evidence that the intensity and proximity of certain uses has made cities, or parts of them, toxic flashpoints detrimental to human and ecosystem health*".

Other studies are concerned with the negative social effects of density. Wirth (1938) is relating high density with different social pathologies caused by greater social distances, differentiation and specialization. Other early studies were also identifying relationships between density and social problems. John Calhoun's (1962) "rodent utopia" was modeling human behavior by placing rats in an insufficient space, observing unwanted social contacts occurring resulting in stress and aggression. The study was influential upon social scientists taking animal studies as model for human population: early approaches looking at the impact of crowding and density were mostly using a single variable, which was usually density. An example is Freedman (1975) making individuals completing tasks in laboratories under varying conditions of density, displaying some social pathologies potentially relating to crime. Baum et al. (1980) looked at the impact of internal residential density focusing on corridors, finding that pathologies resulted from increased and unwanted social interaction. Other studies extended the variables with qualitative aspects of density. According to Newman (1972), the number of dwellings per entrance is an important factor affecting crime rates in apartment blocks (Burton, 2002). Coleman (1985) linked high crime rates to the dominance of shared space, and more specifically related to four design variables: dwellings per entrance, dwellings per block, number of storeys and number of overhead walkways. In relation with security, it's also

important to look at the dynamics between areas with different densities: in the context of the United States, flight of the middle-class population to the suburbs leaves the denser inner city urban areas of low socio-economic status, with a higher crime rate and alienation.

Some authors are questioning compact development policies due to their acceptability and - economic, technical, political - feasibility (Breheny, 1997), for people's different locational preferences (Howley et al., 2009, Audriac et al.,1990), let alone for their inefficiency in reducing energy consumption (Breheny, 1995). Sceptics also emphasize the lack of empirical evidence in the debate about compaction policies. Theories of urban economics show a relationship between land values and density (Alonso, 1964, Muth 1969), having implications on housing affordability since restrictions on land supply may increase land prices and rents (OECD, 2012), consumer preferences and as a result on residential density. Though, these implications are dependent of the local context (Dunse et al., 2013). These relationships and dynamics need to be taken into account in the evaluation of densification policies.

3.1.1.3. Compaction policies

Compaction may be a result of market mechanisms or can be achieved through interventions of the planning authorities through strategic plans, local plans and development control (Burton, 1999), therefore debates about ideal densities are important to set up adequate planning policies, regarding a certain balance between individual needs and public interest, moreover intergenerational equity (Molini and Salgado, 2012). Particularly in Europe, compaction policies have been widely adopted and they are playing an integral role in green growth strategies (OECD, 2012), densification being a major objective. Policies for urban compactness can take many forms, one example is using density measures prescriptively, such as setting up minimum density standards. Molini and Salgado (2012) for instance reviews authors proposing minimum residential densities ranging from 12.35 dwellings per hectares to values of 55, or even higher concentrations up to 100 units per hectare. On the other hand, concerns about the outcome, such as negative effects on environmental quality (including reduced room for green space, open and recreational space, the urban heat island effect contributing to energy demand, congestion, etc.) are apparent. In relation to the negative impacts of high density, maximum densities are proposed in many cases, and in relation to the negative impacts of low density minimum densities are proposed in a few cases. Concerning open spaces, OECD's report on compact city policies highlights *"open spaces in densely built-up areas as an indispensable element of a compact city and maintains that ensuring them is among the objectives of compact city policies"* (OECD, 2012:73), putting a focus on good urban design.

3.1.2. Micro-scale approaches to density – the role of the individual's perception

> *"A concept of density based on a simple ratio model does not seem adequate to predict either behavioral or subjective consequences, and the experience of density must go beyond such ratios"* (Rapoport, 1975)

Kevin Lynch (1960), in his book 'The Image of the City', is identifying components of urban space such as paths, edges, nodes, districts and landmarks and assesses their effects on perception - pointing out the role of cognitive processes in understanding and assessing certain spatial qualities. Rapoport (1975) is suggesting that the potentially negative effects of high-density also depend on the perceptual, cognitive factors of the individuals, which are highly influenced by the micro-scale configuration of urban space. A micro level approach to density is therefore in the scope of environmental behavior studies, concerned with the

interrelation of the build environment and human behavior, observing “interaction between a particular density and the perception and evaluation of that density” (Churchman, 2002). operating with concepts such as perceived density, crowding or isolation, and the factors influencing the perception of the environment are (beside the variables of the environment) personal characteristics of the individual and the also characteristics of other individuals encountered (Stokols et al.,1973).

According to Rapoport (1975), the major aspects of perceived density are on one hand the relationship between the physical elements of the environment and on the other hand the nature of social interactions that environment allows, and the way these two factors are “read” by the individual. The crucial factor in the perception of density is the “rate of information” (visual or social) the individual receives (Rapoport, 1975, Bergdoll and Williams, 1990). The relationship between specified environmental properties and the perceived qualities of space is the subject of several researches, and no single model can be set up to describe this relation, as users constantly re-interpret and re-evaluate their surrounding depending on their own definition of quality of life, also dependent of the context (Churchman, 2000). The difficulty of examining the environment’s potential behavioral (or perceptional) effect on the individual or on the interactions between individuals lies in the possibility of an appropriate and systematic description of the environment: Hillier (2004) points out the difficulty to control the architectural variable in research to assess the psychological impact of a certain environment, due to the lack of systematic and comprehensive description of spatial conditions (proposing a configurational modeling of space) – at the same time stating that the only relations that can be found between cognition, built form and behavior are those that are linked to spatial configurations (Hillier, 2004). At the same time Hillier warns not to fall into the trap of spatial determinism: “if social encounters have their own spatial logic and space has its own social logic, the task of research is to understand how they relate morphologically, then the naïve paradigm of cause and effect between environment and behavior can be avoided”. Nevertheless, studies in the field of environmental behavior have been linking the perception of density with some very specific spatial qualities: perceived spaciousness may be influenced by modifying spatial geometry, including horizontal areas and shapes and the quality of boundaries (Stamps, 2009). Bergdoll and Williams (1990) relates the visual complexity of the environment with the perception of a certain density.

Definitions of residential density and related measures (used in the present research):
Population density - number of people per a given area;
Residential density - the number of dwelling units per a given area;
Gross residential density - number of dwellings per developable land
Net residential density - number of dwellings per developable land excluding roads and other uses
Parcel density (Churchman, 1999): area designated for residences measured in floor area ratio (number of square meter of floor space to the size of the lot in square meters), dwellings per hectare
Gross floor area - the total floor area contained within a building including the walls;
Net Floor area - the total usable floor area contained within a building;

When discussing the appropriate measures for residential density of an area, the issue of spatial distribution and variations comes up. As Churchman (1999) points it out, residential density represents an average for a defined area, and the variations within that area are not reflected in the measures above. The problem exists also on the scale of the neighborhood, especially with areas with diverse building types. Different

spatial layouts are affecting the measurement of density, for example local public open space may be scattered or concentrated (Churchman, 1999) which can have major implications without any change in the overall density figure.

3.1.3. Urban imaginary and density – the influence of visionary thinking

Approaches to the theme of density - as a central determinant of architectural form and the quality of urbanity -, have been going beyond purely rational, scientific or technological considerations. Concepts of an ideal density in urbanism and architectural thinking were representing different ideological assumptions (Cuthbert, 1985), even speculations. Ideal urban forms (linked to a certain quality of life) proposed by visionary thinking have been influencing the practice of planning and architecture. The theme of density appears in visionary thinking, in anticipating the ideal size of the city/neighborhood and the population based on the efficient operation of urban systems, as being advantageous in terms of social relations or "reflecting thoughts on intensity of development" (Reiner, 1963). Spatial configurations are reflecting thoughts about "ideal" lifestyles linked to ideal densities (including the "ideal" quality of social interrelations), which may be important to consider when looking at the case studies of the present research. An example may be visionary thinking in the 19th century, where reducing urban density was the mean to ameliorate the negative effects of overcrowding in the industrial city. The garden city concept of Ebenezer Howard (1902) is aiming to bring together the advantages of the city (employment, prospects of advancement and other social opportunities) and the countryside (healthy environment, low rents) and for this anticipating a density of only 1 dwelling per hectares, giving place to 32000 people on 2400 hectares. Jane Jacobs (1961) describes Le Corbusier's Plan Voisin as a high-density garden city, providing 299 dwelling units per hectare with a floor area ratio 7.20 for the individual skyscraper, and a 79 dwelling units per hectare for the whole project[3]. A third influential example for ideal planned densities is Frank Lloyd Wright's suburban utopia, the Broadacre City, with 12.5 people per hectare.

3.1.4. Linking micro and macro

As the variety of the different density related themes above may suggest, taking a position in the 'optimal density' debate on the macro scale also requires taking into account the tools in designing livable high-density environments on a micro scale of architecture. One component of the compact city is compact urban development (OECD, 2012), the two concepts differing in their scale. Creating compact urban neighborhoods is one among the many tools to create compact cities. Adequate design solutions on the scale of the neighborhood and urban block can act on certain compaction policy targets, such as intensity of land use, the proximity of facilities, provision of solutions for mixing usages. Compact urban neighborhoods can be materialized with different building typologies: *"it is important for cities aiming to create a compact city to have a certain degree of flexibility in the choice of urban form and shape of buildings. This point is of great importance for the acceptability and the feasibility of creating a compact city."*(OECD,2012). OECD is identifying key strategies for the compact city, including both macro and micro scale recommendations in order to minimize the negative effects of compaction policies. Some of the recommendations are interpretable on the micro scale of the urban block. Examples of OECD include promoting "high quality urban design to lower perceived density, encouraging the greening of built-up areas", promote walking and cycling environment (OECD, 2012), which are relevant for the present thesis. Accessing the effectiveness and success of the design tools acting on the micro scale can give

[3] Densityatlas.org, http://www.densityatlas.org (retrieved 04-04-2015)

an additional insight to the debate on 'ideal density' on all scales. The following part of the thesis attempts to zoom on architecture, specifically how architecture can influence density measures through structuring space in different ways.

3.2. THEORIES OF SPACE AND SPATIAL CONFIGURATION

Cuthbert (1985) points out that land use and building form are interconnected and inseparable, therefore it may happen that *"density measurements are rendered meaningless because they fail to take account both of the internal spatial matrix and external formal configuration of the building*". Hiller (2004) also emphasizes that the interplay between conditions of density and that of the spatial system is influencing how urban space is functioning. Consequently, the same urban problems (such as those related to mobility) may be tackled with acting on dispersion/densification or poor/good structural configuration. Neglecting the architectural scale (focused on small scale formal configurations) may also lead to zoning plans that are reducing the complexity of spatial systems to single categories of land use. This controversy is putting in the foreground the problem of spatial configurations in the context of the density debate.

In order to carry out a research on the inherently spatial concept of density, theorization of space and the concept of spatial configurations must be also touched upon. A systematic analysis of urban space has been carried out by Christopher Alexander (1977) describing various patterns in the arrangement of the urban environment, patterns that form altogether a certain language. Alexander links components of the physical environment with society, the latter making the former alive, by sharing the common "pattern language", important in the usage of space. Similarly to Alexander, Hillier (2004) points out the difficulty of conceptualizing space as a thing in itself, alternatively linking spatial structures to spatial images of certain kinds of social processes - spatial configurations can be understood in their relation to social structures. The structures of spatial systems are inferring natural movement patterns (Hillier, 1999), consequently "encountering, congregating, avoiding, interacting, dwelling" are depending on an "engineered pattern of co-presence". Hillier aims to carry out a configurational modeling of space to understand how spatial configuration is influencing urban movement, providing different functional potentials, and through that having an effect on land-use patterns and building densities of certain urban areas (Hillier, 2004). Hillier identifies spatial configurations as a major factor influencing the intensity of usage of public spaces and the density of people on it.

Other theories are also examining spatial structures in their relation with social structures: Whyte (1980) links the behavior of people on public spaces to certain spatial features, observing that users cluster in certain locations while other spaces remain empty: spatial organization is influencing how people are distributed in a certain area. While Whyte has no systematic and comprehensive approach to spatial features, some architectural elements are highlighted that are influential in the usage of open space. For Lefevbre (1991), production of space is a social production (space is produced according to the reproduction of social relations). Space is produced through spatial practices (beside representations of space and representational symbolic spaces). Therefore, spatial configurations are characteristics of social formations. Function is conceived according to movement through space - spatial relations are used through intuition, culture and institutions.

As mentioned above, according to Hiller (2004), both the conditions of density and the configurational characteristics of the spatial system is affecting the way urban space is functioning. Ye and Van Nes (2014) are exploring the interrelations between these two

components, furthermore between their relationships with land-use patterns as a third variable. Ye and Van Nes are categorizing urban areas by investigating street network integration, building density and the land-use mixture, based on the values gained with the space syntax, the space matrix and the mixed-use index method. The categories are then linked to the socio-economic performance of that area, which is measured by the GPS tracking of the people's movement density, finding strong correlations. Social and spatial density (both quantifiable and experienced) is interrelated with spatial configuration. In the following section concepts of spatial configuration are looked at in more detail.

3.2.1. Quantifiable description of spatial configurations

Hiller (2004) describes space according to its spatial configuration, which is influential in the configuration of people: *"it is through spatial configuration that the social purposes of a built environment is created".* Hillier explores the (local) configurational effects of certain local spatial relations (types of configurations) and how these local scaled processes are defining global configurational patterns. Hillier provides the example of the boundary for such a local configurational element, which is the simplest level of creating a relational scheme, and the logical distinctions by drawing boundaries are sociological distinctions that are relational in their nature. The boundary emphasizes the discreteness of the interior contributing to a controlled isolation (Hillier, 1984), while the quality of the boundary determines the quality of the connection between the individual units (cells) the aggregate is composed of. Movement across the boundary on the other hand "builds links by contiguity and encounter" – and movement is possible only if there is permeability between the spatial units. Architecture is carrying out the conscious and creative elaboration of spatial configurations into *"socially workable patterns to generate and constrain (…) normative patterns of encounter and avoidance".* Configuration is defined by Hillier as "*a set of relationships among things all of which interdepend in an overall structure of some kind."* While Hillier's focus is not particularly on the theme of density, he points out (in his reflections on the applicability of space syntax research on an urban scale) that *"there is a central dynamic to the spatial growth of cities, which links the evolving grid structure and its natural movement to the distribution of land uses and built form densities"* (Hillier, 1999). Density - particularly the perception of it - is closely linked to measures of aggregation, encounters and avoidance of people, drawing attention on the importance of spatial configurations in the research of density on the scale of architecture as well. Measures of aggregation, encounters and avoidance are influenced by two basic measures in spatial configurations, which are permeability and inter-visibility between the components. The present thesis is analyzing these two measures in relation with spatial configurations.

3.2.1.1. Spatial integration as a quantitative measure of space – patterns of permeability

Hiller is using axial maps (j-graphs) to describe spatial configurations, where locations and connections are represented, and the depth of these relations is measured from the root (which is a chosen reference point). As it is defined*, "j-graph is a picture of the depth of all spaces in a pattern from a particular point in it"* (Hiller, 2004). The less the total depth a certain spatial unit has, the greater its integration in the spatial configuration is, and the integration value is connected to how much movement passes through that spatial unit ("density of moving people", Hillier, 2004). Hillier is making a distinction between four types of spaces, based on their relation to other spaces. A-type space has one connections, b-type has two connections, one to an a-type space and one to an a-type space or an isolated groups of sub-spaces. C-type spaces have two connections or more and part of a ring of connected cells. B-type spaces have three connections or more and on an intersection of two rings of

interconnected cells. The typology influences the quality of the movement going through that space, for instance in what extent that space functions as a space for occupation or for movement. Certain types of movements are following the configurational topologies: one link spaces are occupation only spaces, and the more link a space has the more it will accommodate movement: *"a-space will have no movement other than the starting and finishing in them; b-space will have movement only to spaces they control both access and egress; c-spaces will have movement to space to which they control either access or egress; while d-spaces will be natural attractors of movement. It follows that just as a-spaces are the most suited for occupation because they are the less suited for movement, so d-spaces are the least suited for occupation, because they are the most suited for movement."(*Hillier, 2004) The ratio of spaces for movement and occupation is important, influencing the amount of movement and therefore *"patterns of co-presence and co-awareness of those who are not brought together in the local functional sub-complexes of the building".* Occupation and movement are understood as generic functions, to *"occupy space means to be aware of the relationships of a space to others, that to occupy a spatial complex means to move about in it, and to move about depends on being able to retain an intelligible picture of the complex"* (Hillier, 2004). A characteristic feature of a certain spatial configuration is the space-link ratio, which is the number of links plus one over the number of spaces (Hillier, 1986).

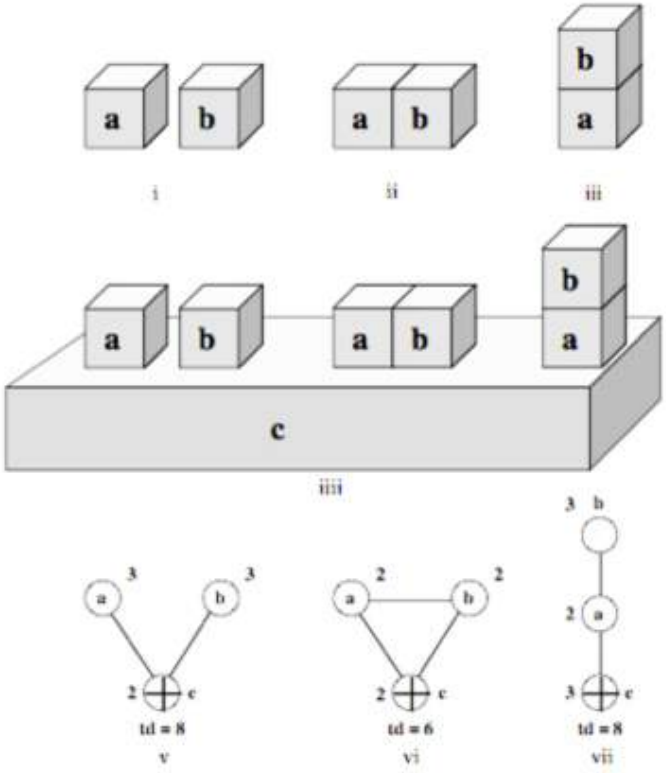


Figure 3.: modifying configurational relations are modifying the quality of the composing elements as well. In a simple relation (above) A and B are symmetrical, while in a configurational relation (below) A and B are becoming assymetrical with respect to C. On the bottom the j-graphs of the configurations are displayed, with a total depth 8, 6 and 8 (the addition of depths from all nodes). Source: Hillier (2004)

Hillier's method to visualize spatial configurations is based on the representation of shapes as a "regularly constructed mesh of cellular elements", which can be "treated as a graph, and thus expressed as a pattern of universal graph distances". This way plans may be also represented as graphs displaying the distribution of centrality and universal distances

(Hillier, 2004). This thesis uses a similar method of overlaying a grid to process architectural plans, not only to examine spatial relations but also distribution of density. For instance, in the research of Tate Modern Hillier et al. (1995) compares shortest path length (average distance from each grid location to all grid locations in the system) with the average occupancy of the rooms in the gallery and appears to find correlation between the two, reaching the conclusion that movement patterns are connected with spatial configuration (Turner et al., 2001).

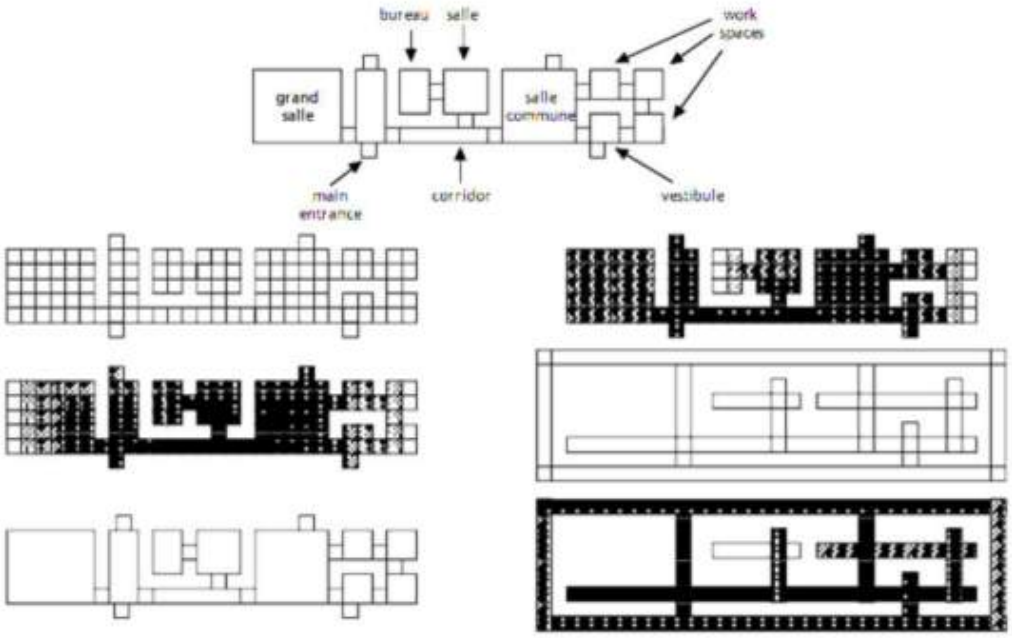


Figure 4.: representation of architectural plans with a mesh of cellular elements, with the degree of integration displayed in each cell. Source: Hillier (2004)

3.2.1.1. Visibility as a quantitative measure of space

While spatial connectivity (and related to that spatial integration) between the different spatial units can provide information about how spatial configuration may influence movements through space, visibility is also a defining characteristic of a certain layout. Hillier describes visibility as the "visual extension to the metric presence", that may influence both usage and perception, even if no movement occurs between the spatial units. Turner et al. (2001) points out that visibility influences the usage of space affecting the decision making process when navigating through space. Furthermore, visibility features are marking the key locations within a complex spatial configuration where decisions are made in the process of finding one's way. Visibility influences the "potential for perceivable co-presence in a space and therefore the potential to form groups or to interact" (Turner et al., 2001), in a similar way to the permeability of the spatial units allowing movement. Visibility analysis is therefore useful in behavioral studies and when examining the perception of space by its user. For example, Turner et al. is referring to Arrude Campos (1997) who is finding correlation between the number of people using a certain urban space and the number of axial lines (lines of sight) intersecting in that space. Different methods have been developed to analyze visibility.

Mapping space by 'isovists' is a method, which has been applied since the 60s to describe visibility in space in a quantitative way (Turner et al., 2001). An isovist is the representation of all visible locations from a certain point in space. Space can be mapped by a number of isovists from specific points in a spatial system – and the interplay of isovists is in

relation with the way space is experienced. Hillier (2004) derives visibility graphs from isovists, and these graphs show the mutually visible locations in a spatial configuration. Though, Turner et al. (2001) points out the limitations of using isovists for spatial analysis: on one hand, due to the geometrical formulation, the isovist measures only local properties of space. Also, the "internal visual relationships within the isovist is ignored", furthermore he emphasizes the difficulties in usefully interpreting the results of such an analysis. Producing an isovist graph also requires the initial selection of the appropriate sets of isovists, which selection may be arbitrary.

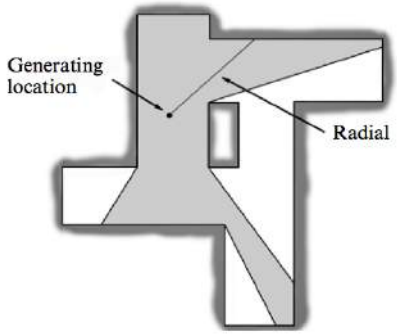


Figure 5.: Isovist. Source: Turner et al. (2001)

An alternative method for analyzing visibility within a spatial system is using axial lines. Axial lines are the fewest longest lines of sight, and an all-line axial map - as Turner et al. (2001) defines it -, is the representation of "all lines that form a tangent between any pair of mutually visible verticles are drawn". Turner denotes the drawback of the axial line analysis as well: " each line or convex region is represented by a node in the graph, and so only a single graph measure can be defined for points along the whole length of the line, or all points with the region". The thesis is going to use a modified and simplified version of the axial line analysis, presented in detail in the 'methodology' chapter.

The aim of the analysis of spatial configurations is looking at objective measures of space and comparing those with the actual usage and experience, in present case the experience of density. This brings up the theme of experience of space, which is inherently subjective and needs different methods to investigate.

3.2.2. The subjective experience of space

Hillier's method is an attempt to represent space in a quantifiable way, going beyond the common architectural representation methods of plans, perspectives and sections, at the same time linking representation of space to social processes. A counterpoint to this approach, spatiality may be understood as a realm of subjectivity. While experts conceive space as abstract and quantifiable, Lefebvre (1991) points out that the user's space is lived and not represented: "*the space of everyday activities of users is a concrete one, which is to say, subjective. As a space of 'subjects' rather than calculations, as a representational space, it has an origin, and that origin is childhood, with hardships, its achievements and its lacks. (…) It is in this space that the 'private' realm asserts itself, (…) and always in a conflictual way, against the public one."* Lefebvre is distinguishing fixed, semi-fixed, movable and vacant spaces according to the lived experience of space and its appropriation by the user, instead of functional distinctions. The spatiality of Lefebvre is *"inhabited by subjects, it might legitimaly be deemed situational or relational – but there definitions or determinants would refer to sociological content rather than to any intrinsic properties of space as such. The restoration of*

the body means, first and foremost, the restoration of the sensory-sensual – of speech, of the voice, of smell, of hearing." Sensory experience is central in Steen Eiler Rasmussen's description of space as well, as a counterpoint to theories trying to objectify space and describe it as a structure or a system. Rasmussen's analysis is based on complex sensory experience, inherently based on qualities such as hardness, softness, heaviness, lightness, etc.: *"it's not enough to see architecture; you must experience it. You must dwell in the rooms, feel how they close about you, observe how you are naturally led from one to another"* (Rasmussen, 1959). Not only the importance of subjective experience, but also of movement according to spatial relation is apparent in this observation of Rasmussen. The subjective experience of space (and therefore spatial density) is in the scope of environmental behavior studies as presented in chapter 3.1.2, attempting to describe subjective spatial experience with the tools of natural sciences.

To summarize, configuration of space (permeability and visibility between the units composing a spatial system) is influencing objective density measures through its impact on the configuration of people. Configuration also has an influence on the subjective experience of density. Therefore, social and cultural meanings given to a building through its configuration may be to a less or greater extent correspondent to the density planning targets defined according to various objectives mentioned before in the 'ideal density' discussion. Neighborhoods and buildings with different spatial configuration will meet in different ways users' "expectations" from a certain density, bringing attention to the relation of the user's experience and assessment of density, and certain characteristics of urban form.

3.3. EXPERIENCE OF URBAN SPACE AND THE DENSIFICATION OBJECTIVES

In capitalist democracies social choices are made either by political decisions or economic decisions, based on individual values (Arrow, 1963). The decisions are based on a comparison of the utility of the potential results of the choices: individual economic decisions realized through market mechanisms, collective choices realized through voting and policies. Despite the various benefits of high density, realizing it is not evident, highlighting the political factor in achieving compaction. Alexander and Tomalty (2002) mentions the opposition of developers and homeowners to the compaction agenda for its consequences such as congestion or gentrification, highlighting the controversies around the political feasibility of the compact city - that is a major arguments against compaction policies. Accordingly, Molini and Salgado (2012) cites various authors who are arguing against compaction for the low-density living preferences of the population and the lack of popular support.

The present section of the thesis examines how individual consumer choices - involving different preferences for urban environments and residential location - may lead to the materialization of urban space with different physical properties, including density or spatial configuration. Putting locational choices in the scope of this thesis is for justifying why certain implications of density and spatial configuration are investigated and others are not.

3.3.1. The density debate and locational preferences

As other social choices, urban dispersion or compaction is a result of either market mechanisms or may be achieved through planning policies or other interventions (Burton, 1999). The ways market mechanisms are influencing land use is many-sided though: according to Carruthers and Ulfarsson (2008) and Brueckner (2000), sprawl may be explained beside

basic human ecology with market failures of different kinds, such as not internalizing certain costs of dispersion.

Causes of dispersion or compaction or other spatial settings, among others, may be changes in residential location choices, including consumer preferences and changing cultural and economic trends (Filion et al., 1998). Density has a certain social significance (Churchman, 1999) and that influences locational choices. According to Howley et al. (2009) a direct connection exists between consumer behavior, locational preferences and residential mobility, and residential preferences have been increasingly influential in mobility patterns. Housing satisfaction is crucial to residential consumer behavior (Howley, 2010), and housing satisfaction can be linked to measures of density, more precisely the experience of that density. The acceptability of high density by residents is one of the most neglected aspects of the compaction debates (Breheny, 1997): housing demands contain a certain locational preference for an area, and public preferences on housing types may point in a different direction than the compaction policies do (Couch, Kachera, 2006 and Howley et al., 2009). Audriac et al. (1990) points out that compact development is often encouraged by the "problematic assumptions that the containment of urban sprawl is tantamount to a better quality of life", not reflecting people's preferences and tastes. While, in certain cases, inner urban areas are successful in gaining population (particularly in attracting young, skilled professionals), Howley (2010) raises the question if the recently regenerated high-density urban residential projects are sustainable on a long term, in terms of keeping a substantial amount of population in the urban cores, due to their transient nature of residential satisfaction.

3.3.2 Factors influencing locational preferences

Locational preferences depend on one hand on the local planning, social and economic context (macro scale factors) and on the other hand on the quality of the neighborhood and the individual's perception of the environment (micro scale factors). The quality of the neighborhood incorporates its density and its spatial configuration as well. Factors influencing the perception of the environment are therefore connected to density and spatial configuration. This section tries to collect density and configuration related characteristics of the built environment that are relevant in locational preferences.

Filion et al.'s model emphasizes the importance of space, place and proximity in the shifts in residential locational preferences (space related to metropolitan wide accessibility, place with home and neighborhood features and proximity involving convenient access). Some of the major factors influencing locational choices are the lot and home size, social homogeneity, quality of life, the secureness of the real estate development, individual preferences for quietness, environmental stimulation and aesthetics (Filion et al., 1998). Further factors are the status expressed by the neighborhood, meanings given to certain physical features (emotive attachments), the accessibility patterns and crime problems. Single-family homes are rather associated with privacy and a favored homogeneity in the building type. Audriac et al. emphasizes the importance of the desire of privacy, the appeal of a rural ambiance among others when looking at the reasons of preference for low-density living (Audriac et al., 1990). The loss of privacy may be a negative adverse effect of densification initiatives, also, the "insufficiency of open spaces in the city center may be an incentive for people to leave high-density areas to live in lower density areas" (OECD, 2012). Churchmann (1999) identifies the following design variables that influence perceived density: neighborhood size, space between buildings, visual and functional accessibility from dwelling unit to open spaces, respect of privacy, division into small clusters, number of dwelling units using the same entrance, noise infiltration, elevation design, location of community services and parking. Walton et al. (2008) uses variables to map perceived neighborhood quality such as building

aesthetics (density, volumes), noise, privacy, green areas, welfare services, maintenance, environmental health, transport services, neighborhood accessibility, environmental stimulation and several measures are linked with building density (building aesthetics, internal practicability, welfare and transport services, maintenance). According to Walton et al. medium density neighborhoods score overall better, even though not significantly.

3.3.3 Locational preferences and spatial organization of the neighborhood

The factors that are influencing locational preferences but not related to the spatial organization of the built environment are not in the scope of the thesis. Others are (a) related to the social interactions influenced by the spatial qualities of the built environment, or (b) directly related to the interaction between the individual and the built environment.

a) Relationships between users influenced by spatial organization: wanted and unwanted social interactions, crowding, privacy, isolation, fear of crime

While there is no determined and direct link between spatial organization and social interactions, according to Hillier (2004), spatial configuration – through affecting movement and density of people - may define patterns of co-presence and co-awareness among the users of space, and therefore influence social interactions. According to Rapoport (1975), density can be understood in terms of social interaction, actual, desired, or perceived, pointing out the relationship between interactions between individuals and the built environment. *"Involved are the various sensory modalities, the mechanisms for controlling interaction levels – spacing, physical elements, territorial boundaries, hierarchy, the size and nature of the group, its homogeneity, rules for behavior, and so on and how the facilities available are used – all of which affect the rates of social interaction."* Several of these specific features are interrelated with spatial configuration. Negative subjective experience of the environment may be a result of low densities, causing low level of interactions (isolation) or of high densities causing the lack of privacy, which Rapoport defines as a control of unwanted interaction.

The fear of crime and other safety concerns are important factors pushing locational choices towards low-density and homogenous neighborhoods (Burton, 1999), micro-level features of a neighborhood influencing the actual and also the residents' perception on crime risk (Foster et al., 2013). The fear of crime may be linked to different spatial properties of an area, including its density and its spatial configuration as well. Literature generally focuses on one of these two factors but does not link them. Burton identifies a negative relationship between population density and crime risk, emphasizing that "the measure of population density may also reflect the form or design of housing as much as its density per se" (Burton, 1999). Foster et al.'s research on perception on crime risk shows that strangers attracted to a neighborhood may be interpreted as a threat to safety, while the physical and programmatic features of the area has an effect on the degree an area is opened for outsiders. On the other hand, Jacobs (1961) promotes that 'eyes on the streets' –surveillance - enabled by rather dense urban environments contributes to the feeling of personal safety and reduces crime risk, also suggesting a certain relationship between density, the form of the built environment and the perception of safety. Even though perception of crime is often linked to the density of the neighborhood, spatial patterns may be just as important in generating socially unaccepted behaviors (Friedrich et al., 2009), contributing to a certain perception of crime. This also suggests that there is an interplay between the densities of a certain area and its spatial configuration, which results in a certain usage and experience of an environment – highlighting the necessity to investigate the relation of density and spatial patterns.

b) Relation between user and physical environment – accessibility, aesthetic stimulations

Several studies are concerned with the effect of the settings of the physical environment on the perception of space. Dieleman et al. (2001) points out the role of urban form and design (both on a macro and micro scale) in influencing travel behavior and related to that, accessibility – even tough this relationship is ambiguous and complex. As for aesthetical stimulation, according to Bergdoll and Williams (1990), (analyzing the relationship of perception of density and visual complexity) low density is associated with greater building articulation, smaller buildings or less façade area, a greater number of "house"-like dwellings. Physical settings and aesthetic features may influence the individual experience of density and therefore the assessment/satisfaction of users.

The thesis - drawing on the literature above -, is focusing on the factors which are directly linked to the spatial settings (and therefore density, its distribution and related to that spatial configuration) of the case studies. These are: relation between users (including quality of social interactions, safety, privacy), and relation between user and the built environment (accessibility, aesthetic qualities).

3.3.4. Architectural design and the densification debate

As some of the examples above may suggest, certain disadvantages of the dense urban environments (and the compact city in general) can be partly managed by adequate design on a micro level. Elizabeth Burton (1999) points out the importance to focus on certain individual components of compactness "to maximize the contribution of the city to social equity", which may be true regarding other benefits deriving from compactness. The distribution of density (a specific variation of the built within a site) and spatial configuration may be such a component. Howley (2010) suggests the need for more nuanced policies putting more attention on urban design "rather than simply reacting to market-led proposals for high-density urban development". Beside academic research, the inclusion of the architectural component in reaching compaction objectives appears in the domain of planning as well, for instance the TCPA (Town and Country Planning Association) policy paper on residential densities claims that *"higher densities can often be accommodated satisfactorily through use of better, more imaginative building designs and urban layouts"* (TCPA, 2003).

Several questions are rising: how is it possible to materialize and manage the compactness of urban fabric on the scale of architecture through the design process? How successful are different design strategies to configure space? What is the experience high-density environments can offer and how this experience might influence personal preferences for living space? Also, as a consequence, how can the acceptability of high-density developments be improved (Bergdoll and Williams, 1990). Assuming that the built environment is related to the patterns of human behavior that are structuring social relationships (Hillier and Hanson, 1984) it's possible to raise the question: to what extent can architectural design address the specific factors influencing the locational preferences of certain groups (such as quality of the relationships between users), in what extent are the spatial order of the case studies "appropriate"?

Certain containment policy proposals are "focusing on the role of the planning system by adopting initiatives that, collectively, promote the compact city" (Breheny, 1995). These proposals are operating on a macro scale, emphasizing the role of planners, and suggesting a rather top-down approach. The successful management of density on a micro scale may on

the other hand influence individual locational preferences, potentially counter-acting decentralization processes in a rather bottom-up manner.

While several researches explore the differences between low, medium and high-density neighborhoods in terms of perceived neighborhood quality (which is influencing residential satisfaction and therefore locational preferences) (Walton et al., 2008), there is little comparative research done about neighborhoods with different spatial conditions in relation with density. Hillier (1984) points out the importance of analyzing the "nuances" of local spatial relationships to understand the global schemes in the configuration of space and the other way around, to understand architecture as an interface between space and society. By overviewing the planning and regulatory context of the projects, a potential critique may be formulated of the current regulatory tools, if they do not provide an adequate framework for architectural design in reducing the wide range of negative effects of high density.

4. METHODOLOGY

A comparative method has been used, aimed to contrast different density distributions and spatial configurations and then, depending on these, identify differences in subjective experience of high density. The case studies are residential projects with high residential site densities (measured in dwellings per hectare) and project area (around 1 hectare), but significantly different patterns in configuration of space within the limits of their sites (distinct spatial layouts). The different patterns in the spatial layout have been preliminary categorized the following way: (1) high-rise freestanding bars (2) low-rise patio/courtyard houses (3) mid-rise freestanding point blocks (4) mid-rise double-courtyard. All project's position within the city is similar, being outside of the urban cores but still surrounded by continuous urban tissue. The research is exploring the variables influencing the subjective experience of density. The choice of the case studies is based on the assumptions made in the expected results (Chapter 2.2) on the relevance of the difference in the spatial layout.

In general, the analysis includes the description of the factors in the design process influencing the densities of the case studies (the overview of the context of planning, such as policies and regulations influencing the spatial layouts, architectural visions and concepts for laying out space), the description of the selected measures of the planned densities of the case study projects, which has been carried out with the overview of planning documents and by participatory observation. Furthermore, users of the projects have been surveyed about how they experience different effects of density.

4.1. ANALYSIS OF OBJECTIVE DENSITY MEASURES AND SPATIAL DISTRIBUTION

Objective measures of density are investigated by (1) mapping the combinatorial aspects of space (*distribution of density*), meaning where is built surface (and where is open-space, distinguished if it's covered or green), (2) how the built is distributed on the given area, furthermore (3) what is the intensity of land use (number of floors). The purpose is to map the variations of density within the project sites. For this, a grid of 2x2 meters is projected on the plans of the case studies, and the plans are translated into that grid. The resolution of the grid should be "human-scaled", adapted to pedestrian usage and movement, furthermore high enough to make possible the translation of refined spatial situations into such an abstract representation – thus a resolution of 2x2 meters has been chosen. A single map is drawn of

each case study containing all the data above, so it can show density degree and its distribution at the same time. This way the plans are comparable and also quantitative data can be drawn out regarding several measures (basic density measures such as dwellings per hectare, floor area ratio, ratio of open and green spaces, open space per dwelling, and more complex measures such as distribution graphs, building heights, density measures weighted by the 'dwelling per hectare' number etc.). Different countries have different regulations for calculating net and gross floor areas. Such a method may help overcoming the complications of comparison in this aspect as well. For reference, a similar mapping method (creating a space-matrix by imposing a raster on the urban fabric) is used by Ye and Van Nes (2014) for measuring "density degree", only on the larger scale of the city, not on the architectural scale.

4.2. ANALYSIS OF SPATIAL CONFIGURATIONS

To map the relational aspects of space (*spatial configuration*), the same grid is superimposed on the projects, so the configuration diagram will be comparable to the density diagram. Only spaces for collective use are displayed on the graph (not the private space of the apartments) and when analyzing spatial configurations, only the area within the project limit is taken into account. On one hand, the setups of the surroundings affect both permeability and visibility: according to Hillier (2004), the more a configuration is integrated internally, the less integrated it is externally and all the way around, which is referred as the paradox of centrality. On the other hand the present research is primarily interested in the ways space could be configured within the project boundaries rather than how that project is inserted in its surroundings. During the architectural design process decisions related to a certain spatial configuration can be made only for the site, while the surrounding is a variable that can't be controlled. Therefore, in terms of the knowledge potentially gained from this research that is usable for the architectural design practice, an approach investigating only the areas within the site may be more beneficial. In the present research only open spaces are examined (the spatial structure of indoor collective spaces, such as corridors, underground parking, etc. is not included).

Two aspects of spatial configuration are investigated, connectivity of the residential units and visibility in open spaces. As for connectivity, a graph is produced representing the circulation network of each project, displaying the possible links (paths for movement) between the units and the exits, furthermore the nodes where these links intersect. Thereby some numerical properties of each configuration can be drawn out, such as the number of nodes, number of links to each node, total path length, path lengths from the residential units to exit or to access specific areas of the project, such as parking, etc. The results will allow the classification of each layout according to its spatial configuration and permeability. While the graph maps all space used for the generic function of movement, a weakness of the method is that it does not differentiate the different paths based on the intensity of movement. A potential further step in the spatial analysis would be to calculate the spatial integration for those fields of the grid where the circulation routes are placed.

In the present research visibility is defined as the number of all cells in the grid you can see from each cell. Visibility is therefore mapped by calculating for each field the number of other fields visible in an orthogonal direction, within the site limits. While this method may not be as refined the isovist method for the visibility analysis of single points in space, there are considerations, which make it preferable. No initial selection has to be made for the "important" points within the layout for what the analysis is carried out. The research is less interested in how landscape or open space is actually organized, but more in what does the specific placement of the volumes mean in terms of potentials in the organization of open

space. With the method above each field can be described by a single number and classified from low to high visibility. An overall visibility can be calculated by adding these values, which can be weighted by the total number of the fields. The weighted number makes possible a direct comparison of the case studies despite the differences in the size of the site and of open space.

4.2. ANALYSIS OF EXPERIENCED DENSITIES

Subjective measures of density are investigated by a survey mapping the experience of density by the users, examining variables related to the spatial organization of the projects *(Annexes 9.3.1, survey design).* Other factors, rather dependent on the wider social, economic and political context, but still influencing the perception of certain kinds of densities (such as the accessibility of services, secureness of the real estate investment, maintenance, etc.) are therefore not in the scope of the study. In order to have a comprehensive assessment of the densities of the projects, two factors are to be examined, with several items (related to different aspects of the perception of the built environment by the residents). The two factors chosen are in strong relation with residential density, locational preferences and the built form as well, as presented in the theoretical introduction. These factors are:

(1) Relations between users – wanted and unwanted social interactions involving privacy, use of public space for socializing, perception of safety/openness for strangers, *(2) Relation between user and environment involving perception of accessibility, presence of uncontrolled spaces, certain aesthetic/environmental qualities*, such as homogeneity, environmental stimulation related the organization of the building masses).

The preliminary assumptions about the connections are:

-Low-rise typologies (patio, courtyard layouts) are associated with low privacy;
-Low-rise layouts are associated with higher perception of crime risk;
-Low-rise layouts are associated with better accessibility;
-Low-rise typologies, as they are characterized with more segmented and inhomogeneous architectural volumes are associated with a more advantageous aesthetic experience.

As supposed, in some aspects low-rise typologies provide a more advantageous experience of density, while in others a more disadvantageous one. While the upper method may not give chance to explore each of the aspects of perception in depth, expanding the research on all the factors above may give a more all-round assessment of the projects.

4.2.1. Risks and concerns

-Cultural context: the different cultural context of Spain and Austria might imply different expectations and perceptions of urban space, as the orientation of individuals with different cultural background towards the physical environment can show significant differences. Different social organization and preliminary experiences may result in different responses to a certain density (Rapoport, 1975). According to Sivam et al. (2011), the preference for the acceptance of different densities is a culturally defined concept: “the public image of a project might be as influential as scales and measurements”. Beside culture, the perception of a certain density is also affected by historical factors, attitudes of policies, economic indicators and changing demographics (Sivam et al., 2011). A challenge for the thesis is focusing on the variables, which are directly related to the built environment, and possibly stay indifferent to

other factors potentially influential. For instance, an example in the literature for culture as a factor is Walton et al.'s (2008) research that finds cross-cultural differences between Italian and New Zealand cities in terms of perceived residential environmental quality in some of the factors linked to population density.

-Socio-economic level, demography: the difference in the socio-economic status of the inhabitants might affect the results, for example higher socio-economic status can mean higher environmental awareness. The lack of data on (1) the average household size/population density of the projects and (2) on the average amount of living space makes complicated to compare crowding, even though it's possible to know household density. The demographic differences may influence environmental preferences, and at the moment there is no available demographic data about the inhabitants of the projects. The temporal instability of the environmental preferences may also be a factor that may influence how inhabitants perceive and assess the urban environment.

-Effects of the certain architectural qualities: the lack of clear patterns in the spatial configuration and the additional qualities of each project that is not necessarily a consequence of density/spatial layout may influence the perception of density and make complicated the comparison, therefore the survey should be designed in a way that pays attention on this issue.

-Occupancy: the case study projects are relatively recently completed, therefore there might be significant differences in the occupancy of the dwellings.

-Language: importance of the language used for communication, translation issues, language barriers.

4.2.2. Data collection

In order to collect data on the perception of the densities of the case studies a survey technique has been implemented. The target population is the inhabitants of the sites, and the survey is conducted among individuals. In order to reach better the surveyed population, a mixed-mode approach may be taken: face-to-face surveys are conducted on the sites and the same surveys are available online. The survey incorporates structured closed and open-ended questions and its organized around four themes (of which the first two are related to spatial organization and density):

-Perception of relations between users related to themes of privacy, crowding, visual exposure, social interactions, and the perception of safety;
-The perception of relation between user and environment related to the themes of accessibility, the quality of space between the buildings, visual impacts;
-Demographic and socio-economic data[4];
-Residential situation[5].

The survey is explained in detail in chapter 5.6.

[4] To get a more refined dataset, items that may be added: education

[5] To get a more refined dataset, items that may be added: number of people living in the dwelling

5. CASE STUDIES

Four residential projects are compared, two located in Vienna and two in Madrid. While the basic density measures (dwelling per hectares, floor area ratio) of the case study projects are relatively similar, the concept for laying out space is distinct: all projects operate with different spatial organizational methods in order to provide certain selected environmental qualities.

Carabanchel Public Housing – low-rise patio

Autofreie Mustersiedlung - low-rise double courtyard

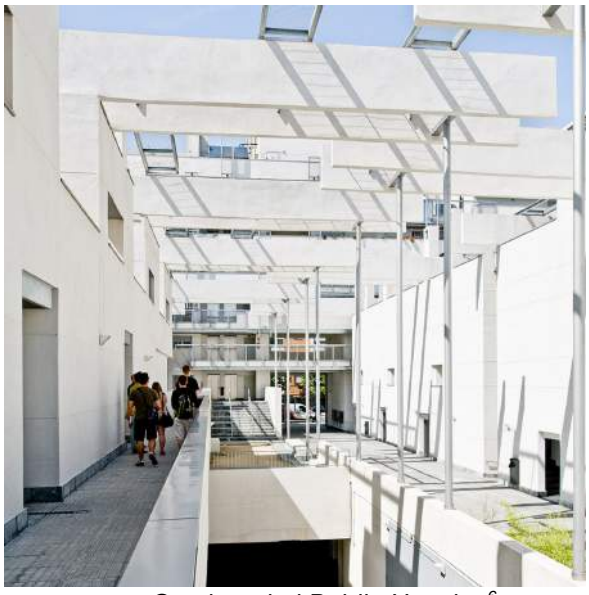
Pradolongo Housing – high-rise bars

Ville Verdi – high-rise point blocks

Figure 6.: Spatial patterns: the aerial view of the case study projects and a square representing an area of 1 hectare
(source: Google Maps, own editing)

These methods are allowing to build more upon opportunities opened up by the specific distribution of the volumes (and density) – such as inserting functions made possible (only) by that specific layout. These qualities reflect certain thoughts about a desired, imagined lifestyles - or even urban ideals-, that is also apparent in the project descriptions. In this sense, the design strategies of the project in how to achieve, handle and take advantage of a certain density are very different. The comparison wishes to reflect on these strategies and assess

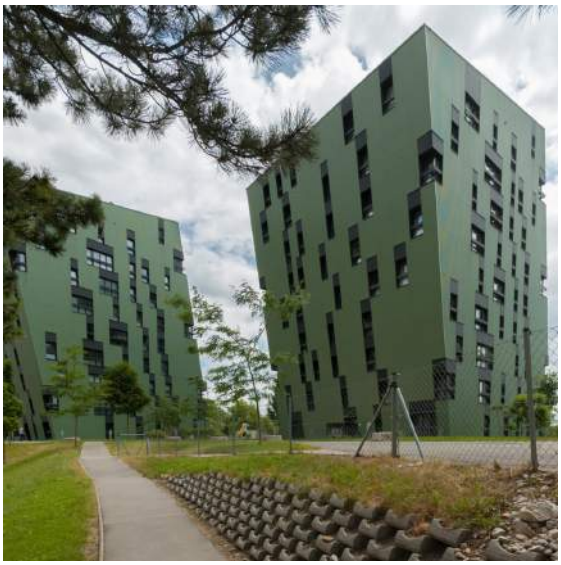
their success. Each case study has been designed by globally recognized architecture firm, which guarantees a certain quality and a presumably successful implementation of the ideas in practice. In general, the projects are on a wide range from low to high-rise layouts. The low-rise typologies (defined here as buildings with up to 6 floors and where the volumes are connected) are rather focusing on community, while the high-rise ones (more than 6 floors, all the case studies operating with independent volumes) are putting an emphasis on the insertion of nature and healthy living – apparent from the project descriptions. Distinct spatial configurations are implemented to meet the objective density targets and the conceptual goals above.



Carabanchel Public Housing[6]

Autofreie Mustersiedlung[7]

Pradolongo Social Housing[8]



Ville Verdi

Figure 7.: Case studies, street views

[6] Image source: Flickr.com, https://c2.staticflickr.com/2/1360/5116456335_d7501a2660_b.jpg (retrieved 17-11-2014)
[7] Image source: Openhouse-wien.at, http://www.openhouse-wien.at/files/images/gebaeude/Autofreie%20Mustersiedlung/AutofreieMustersiedlung4-(c)OHW-OHW14.jpg (retrieved 18-11-2014)
[8] Image source: Archdaily.com, http://ad009cdnb.archdaily.net/ (retrieved 27-11-2014)

5.1. PLANNING CONTEXT

The question of density appears in the broader planning context in what all of the case studies were realized, directly or indirectly influencing the actual legal context (such as construction regulations) and the architectural ideas behind the design. Both in Spain and Austria policies are pointing towards compact development (OECD, 2012) and the achievement of a certain density of the built, people, urban functions, apparent in the strategic plans of each country. Beside the strategic plans, it's important to investigate the regulatory context of the case studies to see in what extent they are appropriate to meet some of the future strategic goals.

5.1.1. Strategic goals in terms of urban density

While there is a general debate about the definitions, measurements, advantages and disadvantages of certain densities, the local contexts in what concentration or de-concentration is unfolding may be very different. The various historical, cultural, socio-economic contexts may result in different adequate policies to address urban densities - such as the implementation of maximum and minimum standards for densities.

5.1.1.1. The Austrian context

Vienna remains a relatively compact city in a European comparison: urban sprawl is less of a current problem, but still an existing threat on what the city's policies are aiming to react. Lechner and Maier (2009) have found – by looking at the density gradient of Vienna – that even though land use patterns are suggesting a rather compact development pattern, the urban area became less compact over the last 30 years. In Austria the Austrian Spatial Development Concept sets the framework for development on the national level, while Vienna has its own Urban Development Plan. The STEP 2025 is the document setting the strategic framework for the urban development of the next decade. The plan is projecting a population growth and setting up objectives to meet the challenges posed by this growth, such as putting an emphasis on multimodal mobility offerings, integration of green spaces in the densely developed urban area. The plan targets the construction of "new areas with a compact, mixed-use approach that is geared towards pedestrian and cyclists in order to create high-quality urbanity". The STEP 2025 points out the underuse of existing urban areas as a problem. The sites of the case studies are defined as areas with development potential for housing, with the goal of providing on one hand sufficient open space and on the other hand to create vitality and diversity on these open spaces.

5.2.2.2. The Spanish context

The compact city has been a historical feature of Spanish cities (Molini and Salgado, 2012) until nowadays, resulting in Spain having the third highest urban density in the European Union and in Spanish population showing a traditional antagonism to suburbanization (Modenes and Lopez-Colas, 2007). Until recently urban sprawl has been less a problem in Spain than in other developed countries, and the main challenge is to address the dynamic increase of the phenomena, a potentially continuous trend due to the lack of sprawl control in the majority of the Autonomous Communities and Municipalities (Molini and Salgado, 2012). Sprawl in Spain is mostly residential rather than economic, and the growth of artificial surfaces is the multiple of population growth - suggesting that policies addressing residential de-

concentrations may be the most efficient in addressing sprawl. In Spain documents giving a framework for residential developments such as the case studies are: Consolidated Land Law, Spanish Strategy for Urban and Local Sustainability, and the Sustainable Mobility Plan on a local level. Madrid's current strategic goals are summarized in the 2013 update of the Plan General (not approved yet though), anticipating a 6% in growth of urban population by the year of 2020 compared to the base year of 2011. Several strategic goals are related to meeting the challenges caused by this expansion, and similarly to Vienna, some of these goals are linked to land-use, density or in general the quality of the urban environment. Overviewing the goals above may help assess if the unique design features of the case studies are more or less appropriate to meet some of the future strategic goals of the city: the document is criticizing certain new developments for not responding the intended growth patterns, for low density, a high consumption of land and natural resources, for the high cost of transportation and energy, the monotony of the urban fabric and low urban diversity, as well as for spatial discontinuity.

The plan aims a compact reformulation of new urban developments according to sustainability goals, involving the achievement of more sustainable urban densities, reducing the consumption of land and the efficient use of other resources such as energy, construction materials, water, furthermore the reuse of existing provisions with optimizing the functional features. Some density and land-use targets that are set are the followings: adequate urban parameters should be reached, such as a higher density (60-100 dwellings/ha), a balance is aimed between residential uses and economic activities, green areas and public roads should not be over-dimensioned in order to avoid the alienation of urban functions and the lack of compactness, furthermore the urban structure needs to be based on the neighborhood as a basic unit. A compact city is aimed with encouraging proximity, which allows reducing the necessary distances to perform basic functions. Unsurprisingly a preference is expressed for sustainable (pedestrian) mobility and the accessibility of public transit, furthermore new developments are supposed to adopt the scale of the neighborhood. Nevertheless, some of the further listed sustainability goals may contradict high-density targets, such as a commitment to a healthy urban environment, involving the improvement of the local environment by noise reduction and better air quality, aiming for biodiversity through the provision of vegetation and trees. The plan recommends the study of the building and street orientation to improve response in terms of sunlight and energy efficiency. The document includes rather general goals and more specific preferable configurational features of the urban structure are less touched upon, but some recommendations are still present. The importance of poles, axes and edges is emphasized: the enhancement of poles and axes is needed to provide recognizable structural elements. Edges are barriers, which should be overcome in order to improve communication and connection between different parts of the city. The structural elements mentioned above can be observed on various urban scales. According to the draft of the new Plan General, Villa de Valecas – a semi-peripheral new urban area in the east of Madrid that is still under development - will accommodate 48.4% of the total population growth between 2011 and 2020. This brings attention to high density neighborhoods with a similar peripheral position relative to the center, where also all the case studies of the present research are located. The success in reaching contradicting environmental goals (such as compactness and healthiness) in the new developments similar to the case studies, is partly the key to fulfill the sustainability goals above, set up by the strategic plan.

5.1.1. Regulatory tools for effectuating a certain urban density

While the strategic plans are drawing up general density targets, the construction regulations are providing the legal framework for construction on each plot. An overview may give a picture of the regulatory tools that are used to effectuate strategic plans and might also allow seeing to what extent these tools are defining the possible layouts (or if these are

controlled later, in the architectural design phase). Only those elements of the regulatory system which are directly linked to building shape are featured in the next chapter (energetic performance, accessibility of disabled people, fire safety, etc. are not in the scope of the research).

In the case of Madrid very different regulations are applicable for the two case studies, even though the net residential density is similar. This result is dissimilar spatial layouts, which are potentially providing a different perception of density. The question can be raised: are the regulatory tools appropriate to control variables linked to an advantageous experience of density (including its various effects)? The following section overviews the most relevant regulations for each case study (without going into detail in the general technical and safety codes applicable for all constructions).

5.1.1.1 Regulations in the Austrian cases

The regulative plan in Vienna is the document called Flachenwidmungs- und Bebauungplan (Local Development Plan), while the construction regulations can be found in Landesrecht Wien: Gesamte Rechtsvorschrift fur Bauordnung fur Wien. The Local Development Plan is the legally binding document defining the areas on the lots that can be built on. Both *Autofreie Mustersiedlung* and *Ville Verdi* are classified as residential areas (category “W”) where only residential functions may be placed. The local development plan prescribes the building lines, which in the case of Autofreie Mustersiedlung gives the possibility of placing two separated volumes on the site. In Ville Verdi the plan demarcates the possible position of the five towers, which approximately matches the position of the actual volumes. Both plots have special provisions to be applied (category “BB”). The main design features that the Austrian construction regulatory mechanism is controlling are the construction lines and set back distances, maximum building volume, maximum building height, distance between buildings, maximum buildable area and green ratio.

5.1.1.2 Regulations in the Spanish cases

Carabanchel Public Housing, beside the general construction regulation that needs to be applied for all buildings in Spain (Código Técinco de la Edificatión), the Plan General of Madrid defines the possible layouts for the parcels. In the case of Carabanchel Public Housing there are special regulations (“condiciones particulares”) customized for the specific parcel. Some key elements of this regulation are that maximum 70% of the total parcel can be built upon, while the whole surface can be used underground. The maximum number of floors is determined (in plano P3’ of Plan Parcial), furthermore the maximum building heights are relative to the number of floors, depending on if the ground floor is arcaded or not. The cornice height of buildings is regulated, those fronting public space must be less then eighteen 18 meters from the street level, and may not exceed 2D, where D is the distance between the axis of the street and the line of edification. The height above attics cannot occupy more than 60 percent of the floor below, and the floor height can’t exceed 3.3 m. There are also regulations concerning the private spaces, which are the following: the private open spaces that are not occupied by buildings above ground must be greened at least thirty percent of its surface, which can also be water and mobile planters. The non-landscaped open space may be occupied by car parks, swimming pools, sport facilities with further regulations (but in the present case non of these options have been applied).

Pradolongo Social Housing is classified in “Norma Zonal 5-3º”, of which construction regulations can be found in the Plan General. According to that maximum 50% of the total

parcel can be built upon, while the whole surface can be used underground, open isolated building blocks may be designed with or without yards, with a closed or opened plot, for residential use. The buildings' position is defined according to its height and the distance between buildings and plot boundaries need to be minimum H/2 but minimum 5 meters with some exceptions.

In general, the main design features that the Spanish construction regulatory mechanism is controlling – similarly to Austria - is maximum building and floor height, distance between buildings, set back distances, construction lines, maximum usable surfaces and green ratio. Both projects had considerable margins concerning the regulations, allowing different design strategies to be adopted. Both in Austria and Spain the regulatory tools are determining a certain maximum volume (that can be used for building), but important configurational aspects of a certain urban layout are not involved, such as integration, connectivity or visibility.

5.2. DESIGN STRATEGIES

Each case study operates with different architectural goals, reached through the specific arrangement of the volumes, resulting in different distributions of density and spatial configurations. These goals may be classified as being either community oriented either nature oriented. The projects where community goals are more important are the low-rise projects with courtyard layouts. The point blocks and bars with high-rise volumes are rather centered on nature, implying the provision of a healthy arrangement in terms of sunshine, ventilation and green. The follow section summarizes each case studies' design targets based on the project descriptions by the design firms and provides a brief description of the realized project, confronting it with the initial plans. The design strategies have been fitted into the regulatory context of each project.

Terms used in the spatial analysis the projects:

- Public space - publicly accessible open space outside the project limits;
- Publicly accessible common open spaces - open space within the project limits, accessible for inhabitants and non-inhabitants as well;
- Private common open spaces - open space within the project limits accessible for all inhabitants but not for the public;
- Private common indoor spaces - indoor spaces accessible only for the inhabitants, such as lobbies, inner circulation spaces, corridors, etc.;
- Private space - other open or indoor spaces accessible only for the owner (apartments, private gardens, etc.).

5.2.1. Community centric concepts based on courtyard typologies:

5.2.1.1. Carabanchel Public Housing – "village like dwelling"

Concept – The design firm Morphosis describes the project as an alternative spatial model to conventional housing by the creation of a "rhythmical structure better resonating with the patterns of the neighborhood," that is "respectful of traditional dwelling customs" with the low-rise structure with loggias evoking a village structured by private and public courtyards[9]. The

[9] Morpopedia.com, http://morphopedia.com/projects/madrid-housing (retrieved 17-11-2014)

majority of the land is built up with two-storey patio houses. A central circulation axis (public plaza, main pedestrian entry) and inner open-space is dividing the plot into two, from where parallel narrow alleys are giving access to the private entrances. Such an alley makes 2-5 units accessible. Some areas in this dense tissue is left open for common gardens, 8 public courtyards are placed in the project. On the northern side of the plot a 12 storey bar, while on the southern edge a 6 storey high bar is closing down the project. Each unit in the low-rise section has a private open-air patio and a rooftop terrace. With such a layout, the project includes apartments with very different qualities, ranging from the patio house to more conventional apartments. The views are strongly limited from the densely built low-rise structure, mostly oriented on the inner courtyards. The inhabitants have no direct access to their apartment from the underground parking, which anticipates a more intense usage of open public space. The layout gives little space for publicly accessible or private common open spaces, especially green space. The site is surrounded with a fence, which is an important feature of the project, so only the inhabitants can access common open space. The narrow alleys are also fenced off at the connection point to the surrounding public space, though the fencing seem to be added after completion and not being part of the original plans. While the large central open space is an important space of pedestrian access, the alleys are opened directly on public space as well, which makes possible avoiding passing through the public plaza.

Image 1. Carabanchel Housing, small public courtyards (source: own caption)
Image 2. Carabanchel Housing, alleys for accessing the patio duplexes (source: own caption)

Project location, surroundings, on-site observations – the project is surrounded on all sides with roads with moderate and only local car traffic. Residential projects are placed on the western and northern neighboring plots, with commercial functions on the ground floor. This is the typical urban typology for the area. On the east the project is bordered by a school, while on the south there is unused open space dividing the built-up area with a highway, which is located around 80 meters away from the site. The stripe between the highway and the housing project may be qualified as low quality green space. The highway is located in a valley therefore is not visible from the apartments, except the ones on the upper part of the 12 story bar. What concerns the interior of the site, the open spaces and also the built structures show a relatively fast dilapidation, signs of vandalism and other potential security problems. While in the original plans the public plaza has a certain amount of green space, the realized state lacks it. A major change compared to the original architectural concept is that the entrances has been closed, providing access only for the residents.

5.2.1.3. Autofreie Mustersiedlung – "car free living and community"

Concept **-** the central idea of the project is to create a car-free residential environment where space initially used for servicing cars is dedicated to community facilities (such as a bicycle repair shop, sauna, fitness room, playground, youth room, roof garden)[10]. According to the architects, the livability of outdoor spaces was central in the planning process. The building incorporates two courtyards. The block is composed of two courtyard buildings, and within each courtyard commonly accessible green is placed. Between the two parts a paved public plaza is placed. The plot connects to public space only on the southern and northern edge, therefore all (vehicular and pedestrian) access routes are from these two sides. The major pedestrian path crosses both courtyards, while secondary paths are placed next to the western and eastern borders of the plots. No parking space or underground parking is provided within the plot, therefore all circulation happens on the open common space. The apartments are connecting to open-space with balconies potentially constituting a more intensive relationship.

Image 3. Autofreie Mustersiedlung, publicly accessible common courtyard (source: own caption)

[10] http://www.schindler-szedenik.at/ams.htm (retrieved 18-22-2014)

Project location, surroundings, on-site observations - On the northern side, outside the project limits a square is placed with playgrounds for children, walking though the square allows reaching Donaufelder Strasse with a tram stop located only 35 meters away from the block. The nearest metro station (Florisdorf) is four stops away. Moreover, on the western and northern areas from the site dense, continuous urban tissue can be found with ground floor shopping facilities. Alte Donau is 250 meters from the site. Within the block, the courtyards and the pedestrian paths on the western and eastern border are planted with dense greenery, the buildings and facilities are in general in a well kept state.

Image 4. Autofreie Mustersiedlung, publicly accessible common in-between space (source: own caption)

5.2.2. Nature centric concepts based on types with freestanding blocks:

5.2.2.1. Pradolongo Housing: "sunshine"

Concept –according to the designer Wiel Arets, the main idea of the design was to create a "spatial relation merging the site and the park", achieving a layout that allows sunlight to penetrate, and where corridors can serve as private-collective spaces. A covered exterior terrace is forming the entry to each apartment[11]. Three parallel bars are placed on the plot, so majority of the apartments are facing each other. The project has similar objectives as Ville Verdi, but operates with more built area, lower building height. Open-space is divided into two with a line perpendicular to the bars: green space is placed on the western half of the plot, while on the eastern half paved open-space is planned. Similarly to Ville Verdi, the staircases are accessible from the underground parking. A part of the ground floor is opened (no functions are placed in this location or there are lobbies with transparent glass walls), granting visibility throughout the whole site from certain locations. Similarly to Ville Verdi, the layout offers comparable conditions for all apartments in terms of view, even though the apartments

[11] Wielaretsarchitects.com, http://www.wielaretsarchitects.com/en/projects/living_madrid/ (retrieved 17-22-2014)

placed on the northern side or on the top floors of the intermediate bar have a different view. On the west of the site Park Pradolongo is located, which may influence the perception of several measures related to density (also touched in the survey). An architectural specificity of the buildings is the cladding used on the facade and certain walls being inclined, otherwise the layout is simple and the single buildings are identical apart their height.

Image 5. Pradolongo Housing, commonly used open-space between the blocks (source: own caption)

Project location, surroundings and on-site observations - Pradolongo Park is located on the west of the site, the southern side of the plot gives place to a recent residential development with a similar layout as the case study itself (mid-rise bars, parallel to the ones in Pradolongo Social Housing). The northern neighboring area is giving place to a large open space with recreational functions, and on the north of that the Hospital Universitario 12 de Octubre. The rather mono-functional surrounding blocks do not include a significant amount of commercial functions and the streets on the northern, eastern and southern edge are used only for local traffic, to access the residential blocks. Calle Dr. Tolosa Latour on the western edge is on the other hand a 4 lanes road with considerable car traffic. Looking at the current state of the development, certain conceptual goals are not realized. There is a lack of refined landscaping within the site limits, the green areas have no intensive greenery; similarly to Carabanchel Public Housing the development has been surrounded with a fence (for the request of the residents), considerably changing the spatial connections and therefore potentially influencing

the results of the research. There is a relative lack of maintenance of open-air spaces, features which features anticipate an underuse of the open-spaces.

5.2.2.2. Ville Verdi: "harmony with nature"

Context - the project is located in Vienna's 11th district in a former industrial zone, in the close proximity of the mixed-use brownfield development of Gasometer. The residential development fits in a larger scheme for the revitalization of the zone Erdberger Mais[12], which aims to reach a population density "suited to the urban location", that is a minimum of 200 inhabitants or workplaces per hectare. The residential function is introduced in the development to support the commercial and service and to provide a certain liveliness to the area.

Concept - The designers of the residential towers were aiming to give a strong identity to the project by setting up a harmonious relationship with the natural environment, putting an emphasis on the position of houses in terms of sunshine. The project is composed of five independent towers, each with 10 floors.[13] As for its layout, the amount of green space is maximized, there is little paved open-space that is serving other purpose than circulation. An east-west pedestrian road connects the five towers, all pedestrian traffic are concentrated on that path. The towers are placed in a staggered layout, so they block each other's view as little as possible and also for maximizing sunshine. All blocks are accessible from the underground parking, which means that if the apartments are accessed by car, the publicly accessible common open spaces do not need to be used. Ville Verdi's concept is the least concerned about community functions, no space is allocated for community, both outdoor and indoor circulation space is minimized, and consequently a high green ratio was achieved. An underground parking is placed below the towers with direct access to the towers' inner vertical circulation cores. The site is not fenced off, many of the pedestrian circulation to surrounding sites happen through the site (several interviewed people were heading to the Gasometer shopping mall or the subway station trough Ville Verdi). The architecture of the towers is rather simple, the towers are identical and offer similar spatial features for all apartments. The specificity of the design is the green texturing of the elevations referring to nature, and the northern and southern walls are inclined. Only a few apartments are equipped with balconies and the openings are rather small. The usable space for apartments was increased by not using inner corridors. Most of the living areas are located on the south side.

Project location, surroundings and on-site observations – on the northern side of the project is Gasometer, separated from Ville Verdi with an open air parking and service space used for docking the commercial spaces in Gasometer. On the eastern side street Otto-Herschmann is dividing the site from industrial areas. The area south of the project is giving place to sport fields, while Hallergasse with small local traffic is neighboring on the west. The site connects directly to public space only on its eastern perimeter. Ville Verdi is rather isolated from its surroundings with the large covered service and parking areas and therefore not pedestrian friendly settings and rather centered on car access. The site itself has well kept green spaces with different areas allocated for specific usages, such as playgrounds for kids.

[12] wien.gv.at, https://www.wien.gv.at/english/urbandevelopment/erdbergermais.htm (retrieved 25-03-2015)
[13] awimmer.com, http://www.awimmer.at (retrieved 20-11-2014)

Image 6. Publicly accessible common space in-between the blocks (source: own caption)

5.3. Basic density measures

Project	**Carabanchel Public Housing**	**Pradolongo Social Housing**	**Ville Verdi**	**Autofreie Mustersiedlung**
Type	*Courtyard* (low-rise courtyard houses)	*Free Standing Blocks* (high-rise bars)	*Free Standing Blocks* (high-rise point houses)	*Courtyard* (mid-rise double courtyard)
Floors	2-3 floors	7-10 floors	10 floors	6 floors
Dwellings	141	144	170	244
Floor area	22000 square meters (gross)	14500 square meters (gross)	14200 square meters (net)	27744 square meters (gross)
Site	1.05 ha	1.2 ha	1.35 ha	1.14 ha
Location	Madrid	Madrid	Vienna	Vienna
Net Residential Density (c.a.)	134 dwellings per hectare	120 dwellings per hectare	125 dwellings per hectare	214 dwellings per hectare
Designer	Morphosis	Wiel Arets	Albert Wimmer	Schindler& Szedenik
Completion	2006	2008	2009	1999/2000

Table 1.: Basic density measures and other data

The basic density measure used in the selection of the case studies is the net residential density measured in dwellings per hectare. Carabanchel Public Housing, Pradolongo Social Housing and Ville Verdi have a very similar number ranging between 120 and 135, despite the very different spatial layout. In terms of net residential density there is no significant difference between these projects, except for Autofreie Mustersiedlung that operates with a higher density figure, which is expected to be reflected in the results too.

5.4. DISTRIBUTION OF DENSITY

Community centered low-rise projects (organized in patios or courtyards) are characterized by a limited amount of open air space (area of built up land divided by area within project perimeter, *Table 2.*) and significantly less amount of open air space for each dwelling *(Chart 1.).* A distribution diagram for each type (green open space, covered open space, 1 floor, 2 floors, 3 floors, etc.) can be generated for further analysis. Lower rise courtyard blocks mean a more even distribution of density, while high-rise layouts operate with a less equal distribution. The statistics below have been produced based on density distribution graphs *(Figure 8.).*

	Carabanchel	Autofreie	Pradolongo	Ville Verdi
Ratio of built-up area	67,6%	42,2%	23,9%	18,8%
Ratio of green space	10,3%	41,2%	43,8%	56,4%
Ratio of covered open-air space	22,2%	16,5%	32,2%	24,7%

Table 2.: Ratio of different land uses, distribution of density

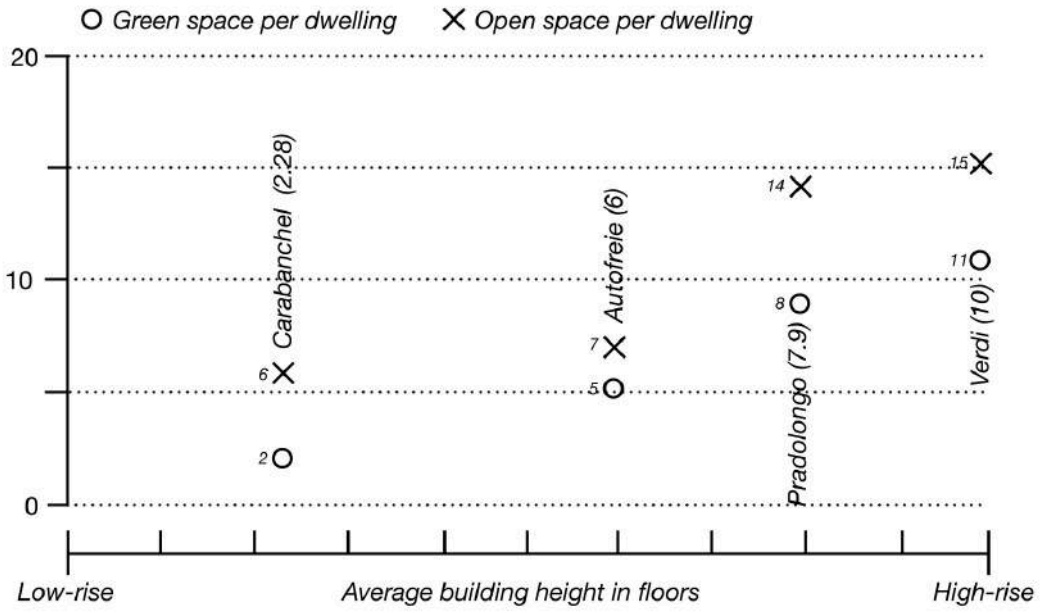


Chart 1.: Open and green space per dwelling, in the number of 2x2m units, source: own editing

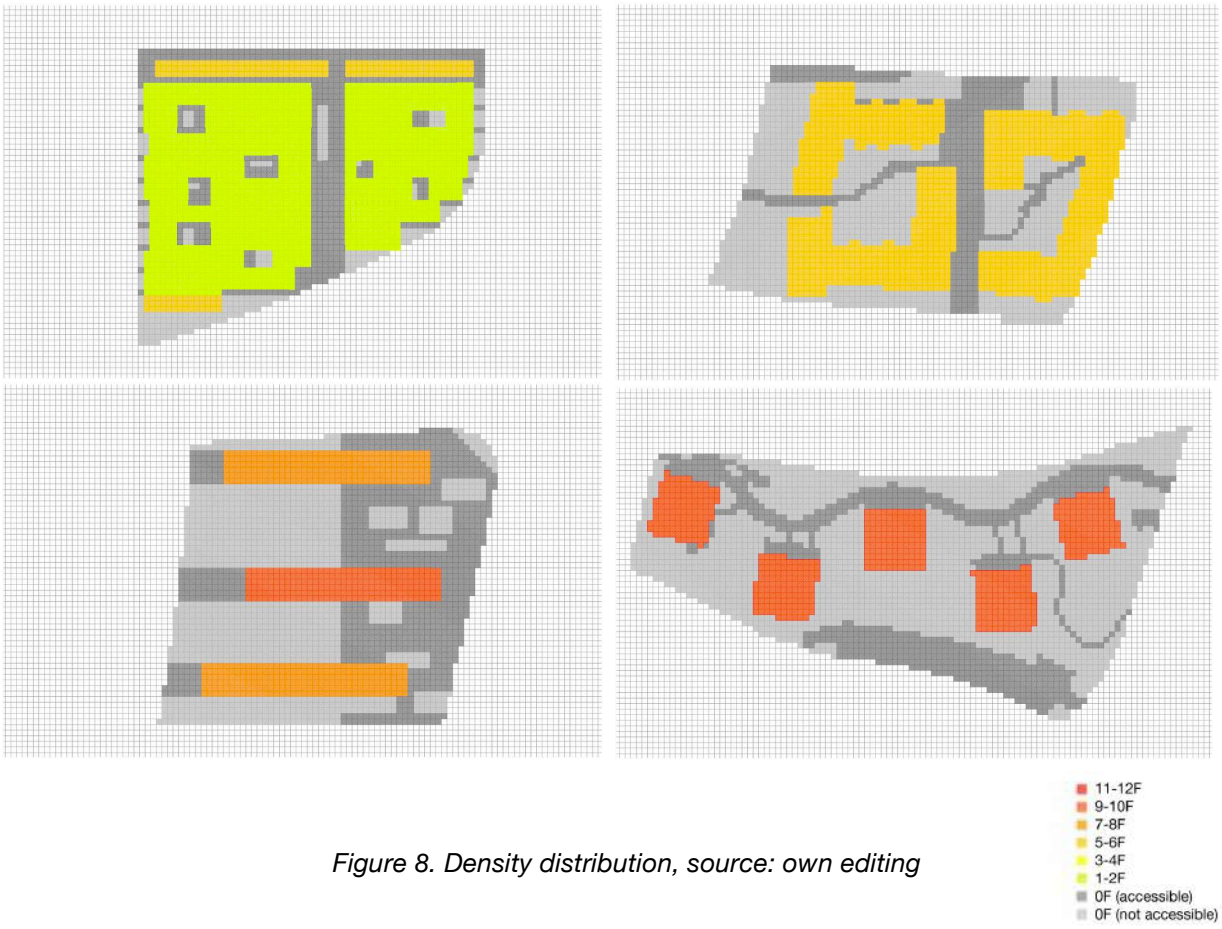


Figure 8. Density distribution, source: own editing

The amount of land used for different functions is different. Built-up area and other private areas: Carabanchel Public Housing uses 67.6% of the land for buildings or opened private patios, while in the case of Ville Verdi, this number is only 18.8% (Pradolongo 23.9%, Autofreie 42.2%). While the overall site area is similar, Ville Verdi provides nearly 5 times more commonly accessible green open space than Carabanchel Public Housing. Pradolongo Social Housing with a slightly smaller green area ratio compared to Ville Verdi, while the ratio of built-up area is different. Autofreie Mustersiedlung has a medium figure for the ratio of the built-up area. The land used for covered open-air shared space is similar. These differences may potentially cause difference in the experience of density as well.

5.5. SPATIAL CONFIGURATIONS

Spatial configurations are mapped using the same grid as for density. The graph of the circulation network is superimposed on the grid. The graphs produced are investigating spatial connectivity and visibility on the collectively used spaces, within the project limits. Certain qualities of the projects must be mentioned here that can highly affect the usage of the projects but are not related to any of the basic density measures. Ville Verdi and Pradolongo Social Housing both have an underground parking that is a major access to the buildings. Autofreie Mustersiedlung on the other hand has no on-site parking opportunity, so all access from public to private space happens on commonly used open-air space. The accessibility of the commonly used open air spaces is also different. While the Madrid cases are fenced off, the projects in Vienna are accessible for non-residents as well. Despite the fences, all former possible entries and exits are functional currently, but only for residents. The fully accessible Austrian projects are seldom accessed by people who are not residents or visitors, an

observation which is based on the high number of conversations held with the users, during making the survey.

5.5.1. Spatial connectivity

It's possible to identify major differences in the spatial configurations of the projects by looking at the axonometric circulation graphs of the commonly used open-air spaces and the quality of the connection to the individual units. The measures used to highlight these differences are the number of nodes in the circulation network, the total length of the paths, the number of exits from the site and the average path length to exit as a pedestrian from each unit (Annexes, Table 4.). The measures above may all influence encounters or visual contact between the residents, therefore potentially the experience of density. An assumption of the thesis is that the distribution of density is related to the number of nodes and path lengths. The fewer nodes are and the more links each other node has, the more the nodes are working as centralities, therefore give more opportunities for meeting (as if there are less nodes, more people are crossing each of them).

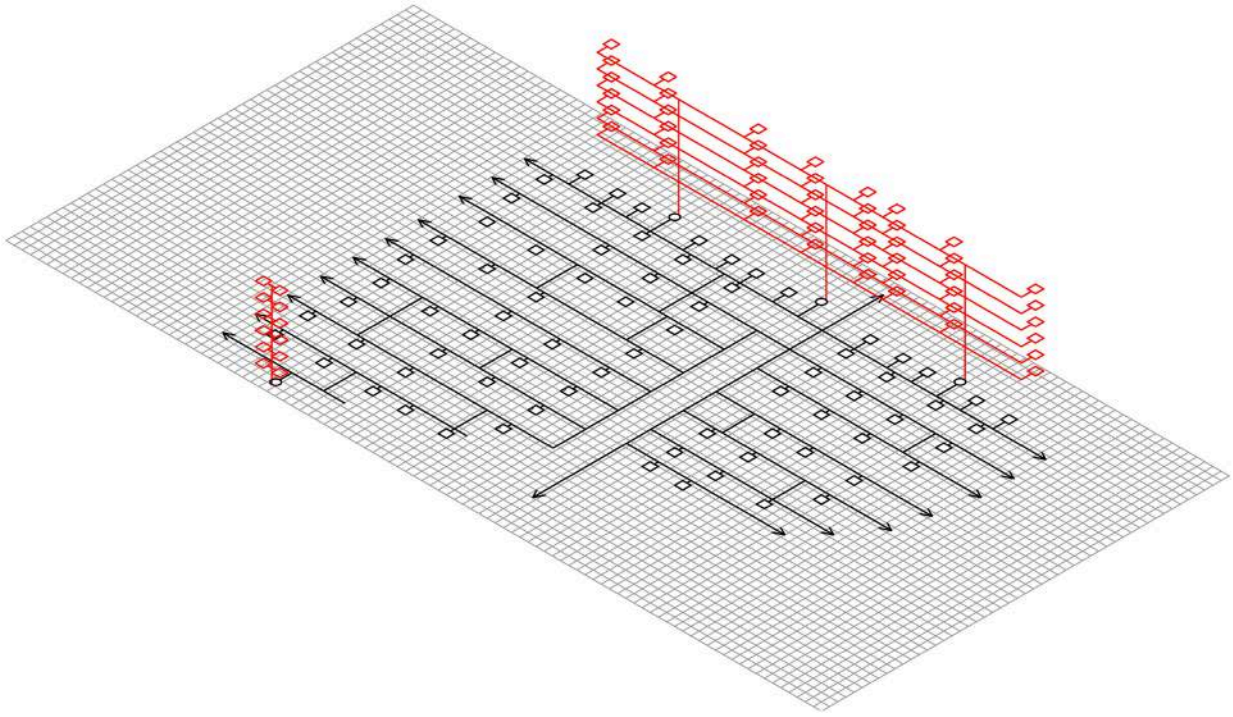


Figure 9. Carabanchel Public Housing, connectivity scheme, axonometric view, source: own elaboration

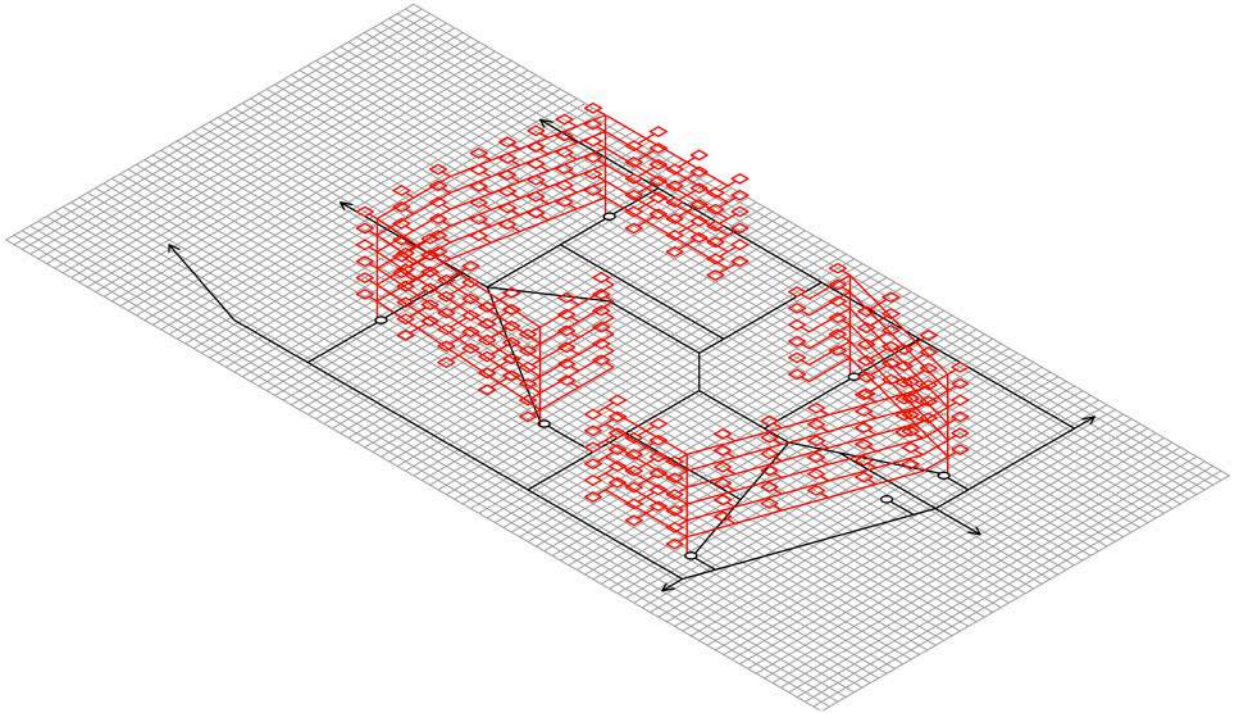


Figure 10. Autofreie Mustersiedlung, connectivity scheme, axonometric view, source: own elaboration

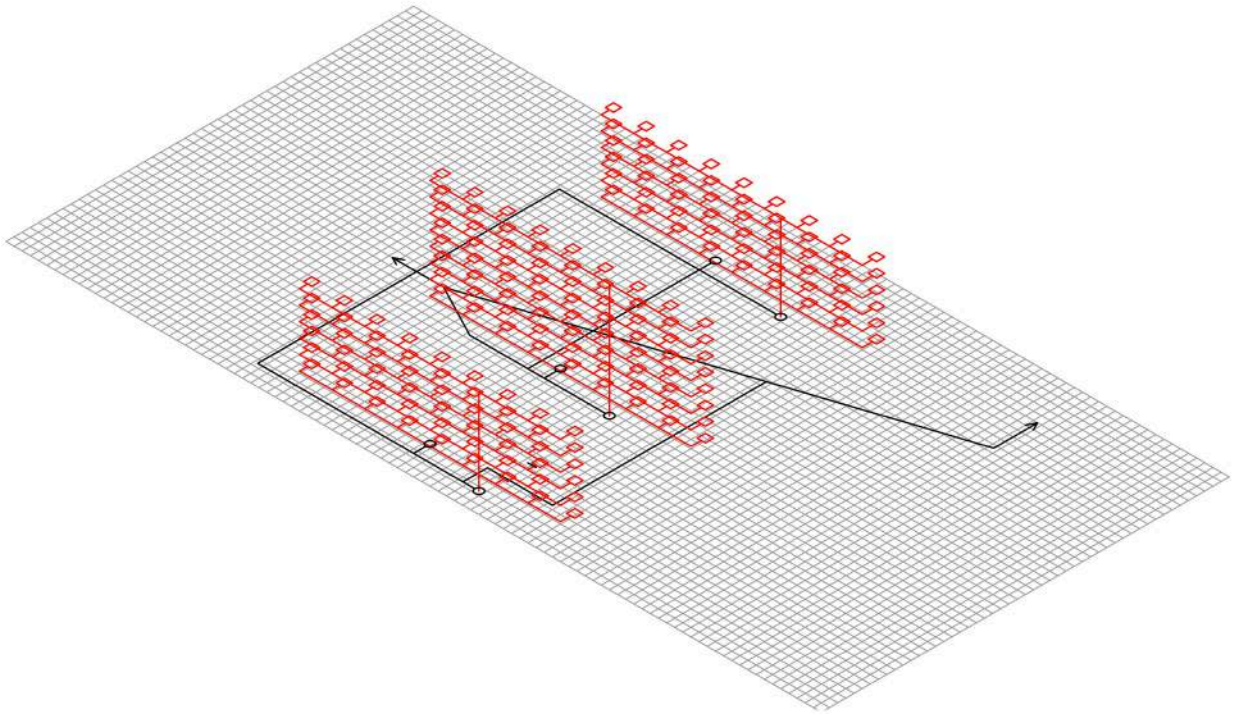


Figure 11. Pradolongo Social Housing, connectivity scheme, axonometric view, source: own elaboration

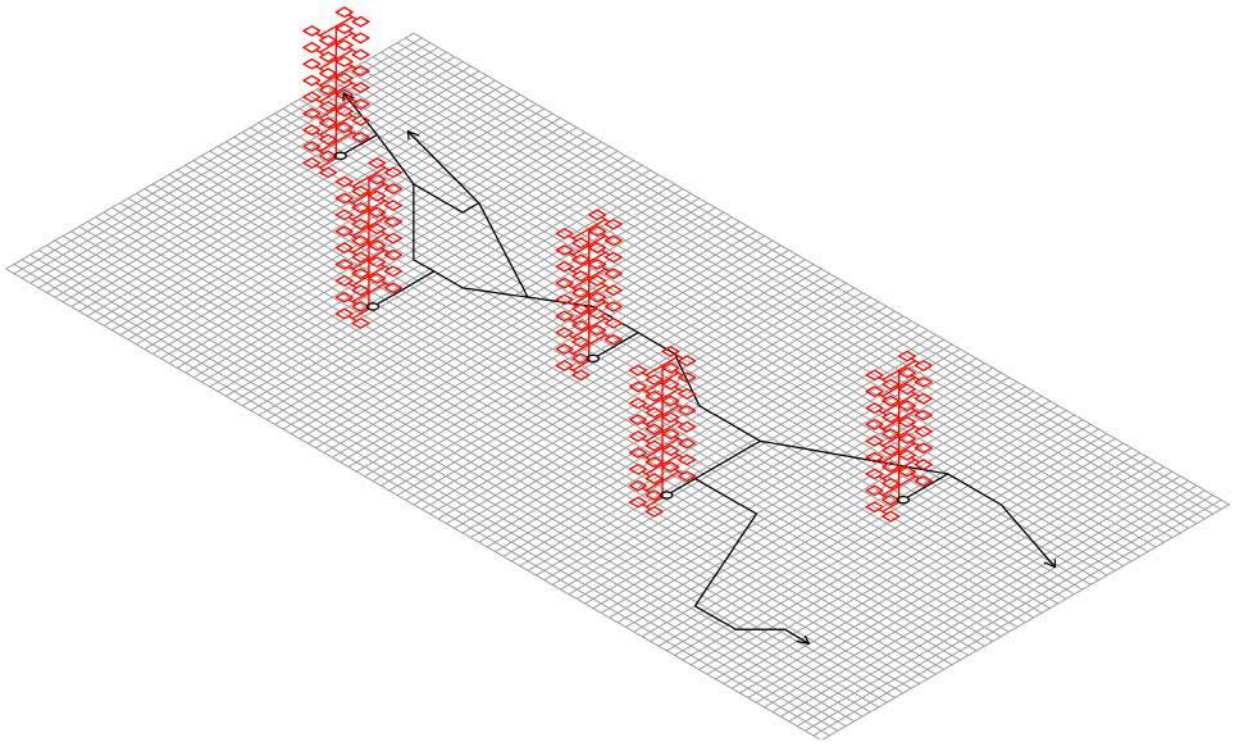


Figure 12. Ville Verdi, connectivity scheme, axonometric view, source: own elaboration

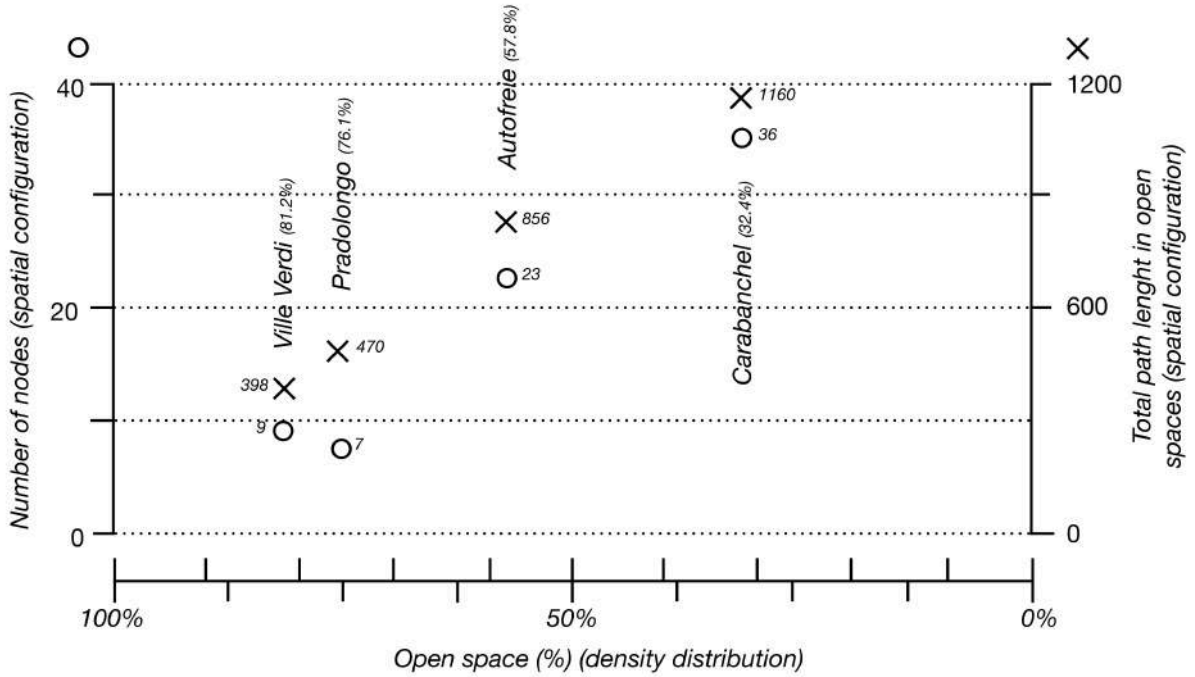


Chart 2. The relation of the distribution of density and of spatial configuration (nodes and path length), source: own elaboration

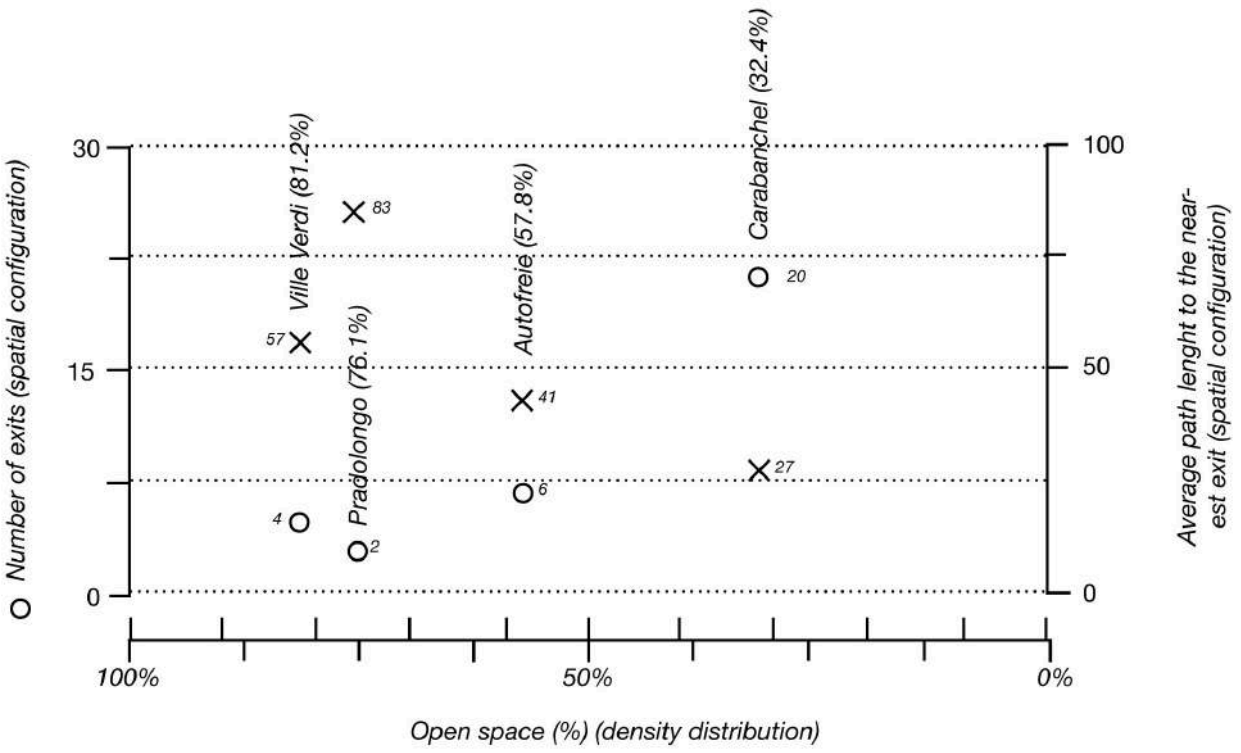


Chart 3. Relation of density distribution and the location of the exits relative to the dwelling units, in the spatial configurations (source: own elaboration)

The spatial analysis of the case studies shows that the spatial systems with a more evenly distributed density (which is the case of the lower rise patio or courtyard projects) operate with a higher number of nodes *(Chart 2.).* The highest number of nodes can be found in Carabanchel Public Housing, while the less in Pradolongo Social Housing: freestanding layouts with a less equally balanced distribution of density have a much less fragmented circulation pattern, apparent in the less number of nodes. Similarly, difference can be seen in the number of exits from the project sites *(Chart 3.).* The possible circulation routes are less concentrated in the low-rise patio and courtyard layouts, while in the case of Pradolongo Social Housing and Ville Verdi all pedestrian circulation happens on a few numbers of routes. The total path length of circulation routes is therefore the longest in Carabanchel Housing, shorter in Autofreie Mustersiedlung and the shortest in Pradolongo Social Housing and Ville Verdi. It can be concluded that the distribution of density is in relation with the spatial configuration and therefore certain functional features of the projects.

5.5.2. Visibility

As a general result it may be said that the case studies are very different in terms of visibility in the commonly accessible open spaces. Low-rise typologies feature a lower overall visibility *(Chart 4.).* The less space is built up and the higher the buildings are, the higher the overall visibility is.

Figure 13.: Visibility map of Carabanchel Public Housing, source: own editing

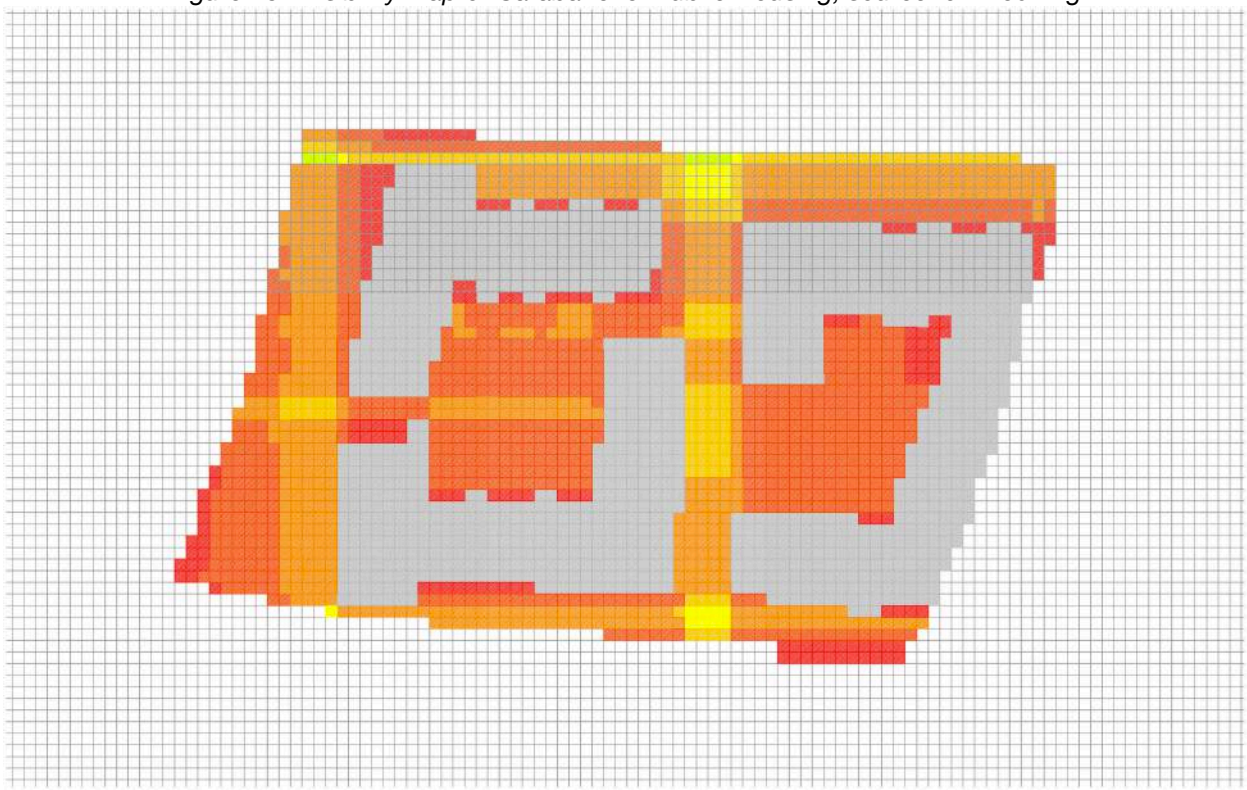


Figure 14.: Visibility map of Autofreie Mustersiedlung, source: own editing

Figure 15.: Visibility map of Pradolongo Social Housing, source: own editing

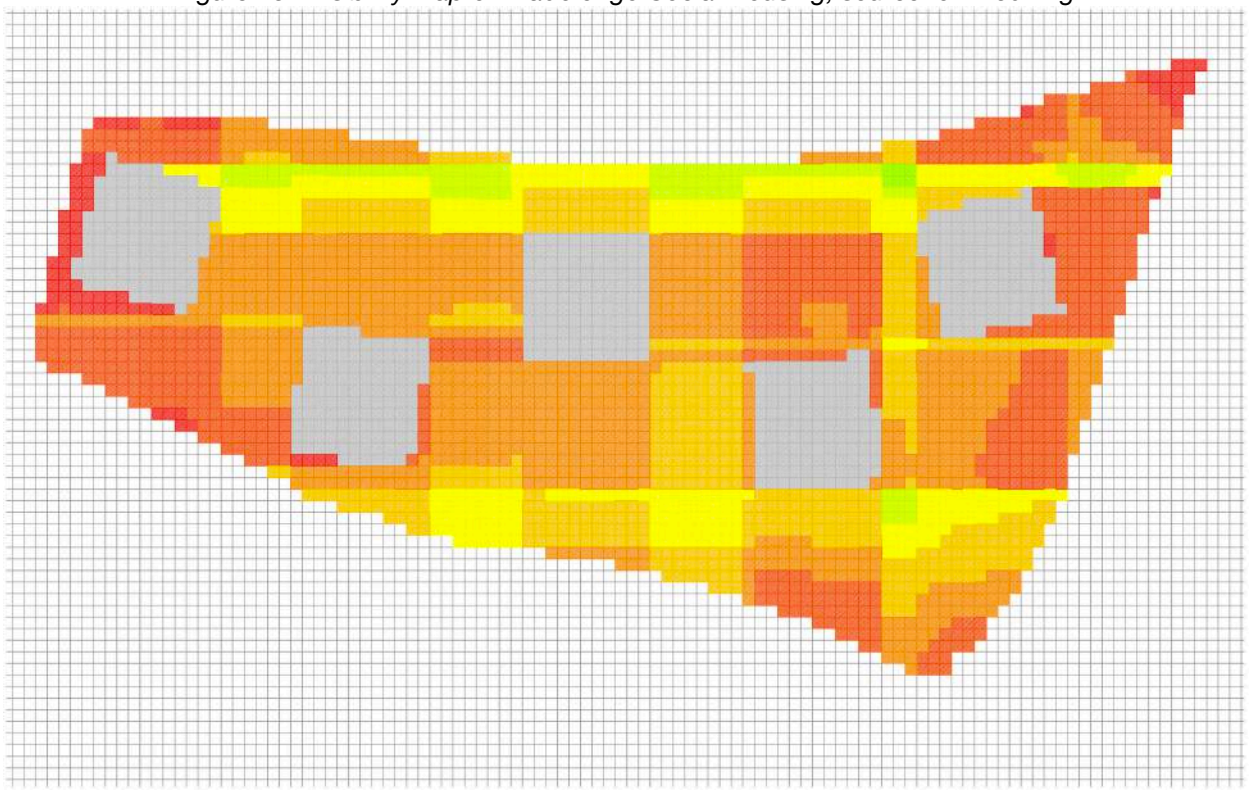


Figure 16.: Visibility map of Ville Verdi, source: own editing

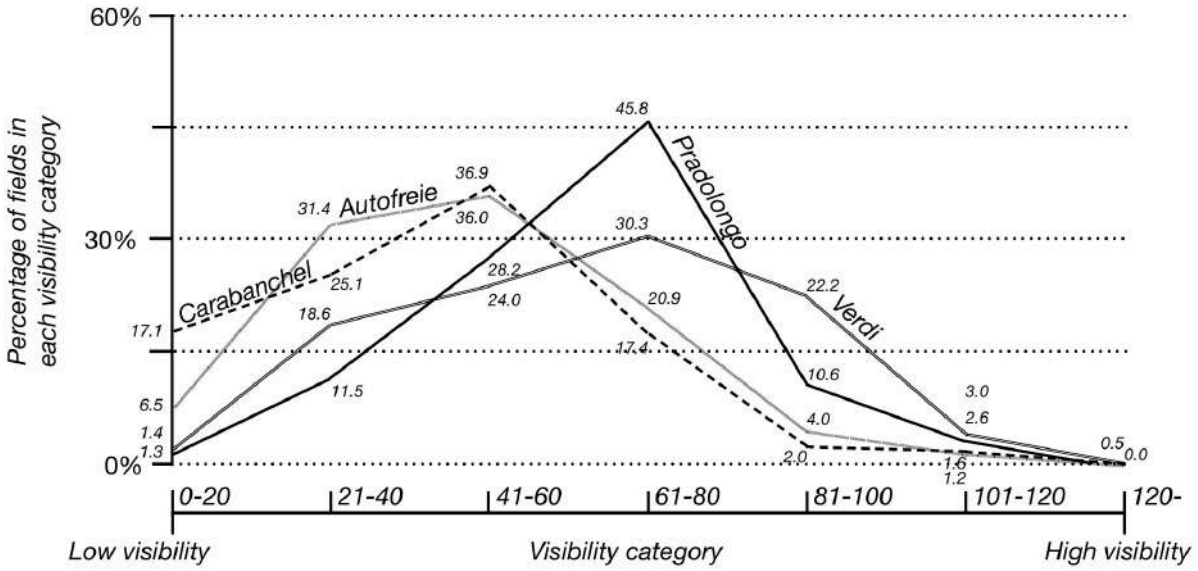


Chart 4. Overall visibility compared, source: own editing

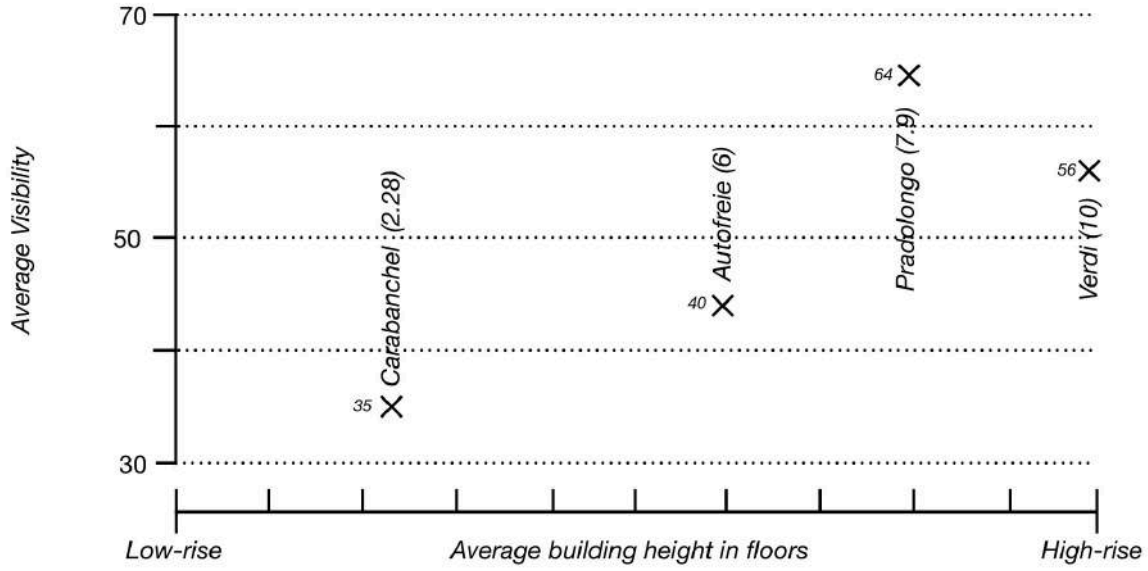


Chart 5. Overall visibility compared, source: own editing

Some further specificities of each project can be highlighted. Carabanchel Public Housing has very low visibility measures in the alleys giving access to the housing units, while the public plaza provides an rather average visibility. Autofreie Mustersiedlung provides low visibility numbers for the fields within the courtyards. Ville Verdi provides high visibility areas, especially in the area where the major circulation routes are placed. In the case of Pradolongo Social Housing, in terms of visibility, there is less variation between the different areas.

5.6. EXPERIENCED DENSITY

The questionnaires mapping the experience of density were filled either on paper on the sites, or online. In the case of Autofreie Mustersiedlung, the link of the online questionnaire had been sent out to a mailing list that could potentially reach 50-60 inhabitants. Out of this,17 person filled out the online survey. Another 13 persons were surveyed on the site. For Ville Verdi, 30 people filled out the survey, all of them on the site. 30 people answered the questionnaires at Carabanchel Public Housing, while 30 surverys have been completed at Pradolongo Social Housing. The total number of surveys completed is 120. As a general observation, the surveys filled online were more successful in getting answers for the open-ended questions. The dates for surveying were the following:

Carabanchel Public Housing: 27th of March 2015, Friday, 1pm-3pm; 29th of March 2015, Sunday, 2pm-4pm; 2nd April 2015, Thursday, 3pm-8pm.
Autofreie Mustersiedlung: 7th of February 2015, Saturday, 10am-12 am; 19th of July 2015, Saturday, 11am-1pm
Pradolongo Social Housing: 3rd April 2015, Friday, 3pm-6pm, 22nd May 2015, Friday, 5pm-8pm, 23rd May 2015, Saturday, 3pm-6pm, 25th May 2015, Monday, 7pm-9pm, 26th May 2015, Tuesday, 7pm-9pm
Ville Verdi: 6th of February 2015, Friday, 1pm-4pm; 7th of February 2015, Saturday, 2pm-5pm, 17th of July 2015, Friday, 3pm-9pm

The surveys mapping the subjective experience of density focused on social interactions/privacy, safety, health and accessibility, all related to the overall experience of density. While the answers given for some of the questions do not show significant difference between the projects, there are themes where the differences are apparent. The following section goes through the four themes above and also analyses the answers given for the open-ended question concerning the general advantages and disadvantages of the block.

5.6.1. Qualitative results - advantages and disadvantages of the blocks

Carabanchel Public Housing - the inhabitants mentioned as a main advantage the good neighborhood, the good accessibility and spaciousness *(Figure 17.).* The major concerns about the block are not related to spatial configuration but rather to construction quality. Nevertheless, living on two floors, disadvantageous views, the lack of leisure, community, green space and space for children were mentioned *(Figure 18.)*. The lack of intimacy came up in several responses.

Figure 17. Carabanchel Public Housing advantages (wordcloud made with worlditout.com)

Figure 18. Carabanchel Public Housing disadvantages (wordcloud made with worlditout.com)

Autofreie Mustersiedlung - the advantages the most frequently mentioned are related to the community and the inhabitants themselves. Respondents point out as an advantage close social interactions, community spirit, responsible inhabitants and the village like ambience of the estate. Furthermore, accessible green space is mentioned as an advantage in several answers, just as walkability and car-free living *(Figure 19.)*. The major disadvantages mentioned in the case of Autofreie Mustersiedlung are mostly related to the building quality, architectural detailing (such as the use of concrete) and the lack of space (low ceiling, lack of collective rooms). Certain inhabitants mentioned the darkness of the flats and the inflexibility of the structures *(Figure 20.)*.

Figure 19. Autofreie Mustersiedlung advantages (wordcloud made with worlditout.com)

Figure 20. Autofreie Mustersiedlung disadvantages (wordcloud made with worlditout.com)

Pradolongo Social Housing - residents mentioned as a main advantage the good location with all necessary facilities and infrastructures around. Besides the convenient location the calmness, good views, good ventilation, light, spaciousness and the proximity of green space have been mentioned *(Figure 21.)*. Few disadvantages came up that could be related to spatial configuration: the lack of intimacy and the proximity of the neighbors were major ones. The complicated access to storage space was a further inconvenience. The rest of the disadvantages pointed out are rather related to details of the design, such as issues with the windows, bad construction quality, wrong choice of pavement. Inhabitants mentioned the low security and the bad neighborhood as a disadvantage. The absence of shopping facilities came up for several respondents as a negative aspect of the development, furthermore the lack of maintenance of green space has also been indicated *(Figure 22.)*.

Figure 21. Pradolongo Public Housing advantages (wordcloud made with worlditout.com)

Figure 22. Pradolongo Social Housing disadvantages (wordcloud made with worlditout.com)

Ville Verdi - the inhabitants mentioned as a main advantage of their block its accessibility. Several respondents pointed out the nice view of their apartments. Other answers included the quality of green space, the lightness of the flats, the functionality and the modern design. Furthermore, the calmness of the area was a positive feature mentioned *(Figure 23.)*. As a disadvantage, the most answers pointed out the windiness of the apartments, and the lack of bike storage. Other disadvantages brought up were the lack of sufficient parking and the lack of space for the youth *(Figure 24.)*.

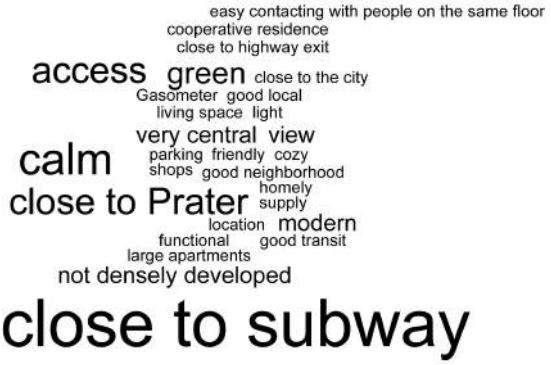


Figure 23. Ville Verdi advantages (wordcloud made with worlditout.com)

Figure 24. Ville Verdi disadvantages (wordcloud made with worlditout.com)

5.6.2. Quantitative results

An average number has been calculated for each variable/question and each case study, based on the number of answers given for each possible option, on the scale of one to five. The results are represented in the following chart, which will be commented in detail in the following sections of the thesis:

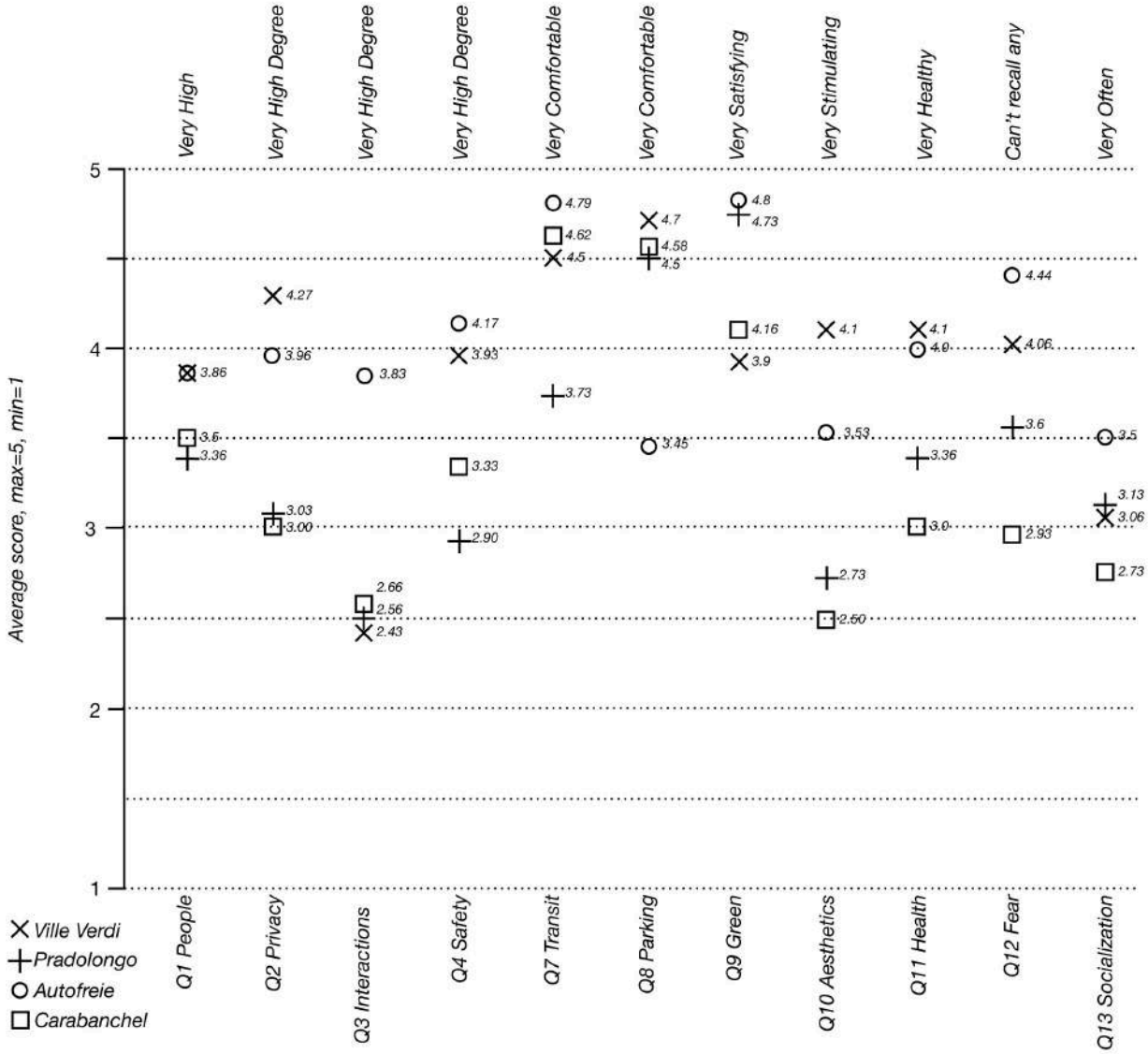


Chart 6. Survey results by questions and case studies,' source: own editing

5.6.2.1. Perception of social interactions and privacy

Certain variables of experienced density, such as the feeling of privacy and the number of social interactions can be very different in the case studies, despite the similar density figures. Overall, the inhabitants of Ville Verdi and Autofreie Mustersiedlung experience the number of people somewhat higher in the block than those of the Madrid cases *(Chart 6., Q1).* The Austrian cases show very similar figures despite the different spatial layout and the different connectivity and visibility measures. Despite the lack of underground parking, the number of people experienced in Autofreie Mustersiedlung is similar to Ville Verdi. The number

of people experienced does not seem to have connection with the internal spatial layout of the projects.

Visual privacy is experienced less in the Madrid case studies *(Chart 6., Q2)* – the most negative answers given in Carabanchel Public Housing. Furthermore, answers for the open-ended questions emphasized the bad views, the proximity of neighbors. Two interviewees complained about the lack of intimacy, though intimacy was mentioned once as an advantage of the block. Carabanchel Public Housing has very different housing typologies, depending on whether it is a patio housing or an apartment in the bar. While there is no data on visual privacy for each housing typology within the project, it can be supposed that low visual privacy figures are associated with the low-rise patio houses, as nothing is obstructing the view in the units located in the bars. Inhabitants of Pradolongo Social Housing also mention a rather low visual privacy despite the freestanding blocks, possibly resulting from the bars placed parallel to each other. Inhabitants of Ville Verdi have the most visual privacy (for the staggered positioning of the towers), while Autofreie Mustersiedlung shows a medium figure (score 3.96), but several interviewees mentioned low privacy as an issue: the lack of anonymity, certain apartments designed with little privacy, the adjacent buildings being too close. It may be concluded that visual privacy is somewhat connected to the distribution of density and connectivity (free standing layouts providing more privacy), but also depends on other details of the layout. The staggered tower layout provides the most privacy, while the parallel bars are not advantageous despite the free-standing typology. The patio layout has the lowest privacy.

The interaction between the inhabitants is highest in Autofreie Mustersiedlung, which is reflected in community appearing as a major advantage in the open-ended questions. On the other hand interaction is rather low in Carabanchel Public Housing, despite similarly being a community centric concepts and having rather similar properties in terms of spatial configuration *(Chart 6., Q3)*. The perception of the degree of interaction in Pradolongo Social Housing and Ville Verdi are comparable to Carabanchel Public Housing, and interaction with the neighbors rarely appear in the answers given for advantages and disadvantages of the three latter projects.

Contradictory results were obtained on the degree and quality of social interactions. In the case of Carabanchel Public Housing respondents mentioned the possibility of socializing and communication with neighbors as a main advantage, but the degree of interaction with the neighbors is not particularly high in the answers given for the multiple choice question (*Chart 6., Q3)*. In Autofreie Mustersiedlung community appears as the main advantage, and the degree of interaction with the neighbors is also high. Respondents emphasized the need and lack of community spaces in both projects. In Pradolongo Social Housing and Ville Verdi community does not appear in the answers given for the open-ended questions. It can be concluded that community is more present and the degree of interaction with the neighbors is higher in the lower rise case studies, which suggests certain connection between the experience of density and spatial configuration.

In terms of the usage of open spaces, despite the intentions of the designers, the inhabitants of Carabanchel Public Housing use the least commonly accessible space for socializing *(Chart 6., Q13).* This may be accounted partly for the fragmented circulation structure with several exits and no main nodes - giving opportunity for less encounter - and the little surface allocated for open-air commonly used spaces.

5.6.2.2. Safety

Similarly to social interactions and privacy, the inhabitants of the case studies experience the safety of their blocks in very different ways *(Chart 6., Q4 and Q12).* Autofreie Mustersiedlung (community centric courtyard project) is experienced safer than its close environment and safer than Ville Verdi (nature centric free-standing project). Also, inhabitants of Autofreie Mustersiedlung can recall less fearful areas within the site limits, except one response stating many. Nevertheless, in the case of Autofreie Mustersiedlungseveral responses mentioned thefts and burglaries. The inhabitants of Carabanchel Public Housing (community centric courtyard project) also experience their block safer than the surrounding areas than the residents of Pradolongo (nature centric free-standing project), but on the other hand they can recall more fearful places (31% and 14%). This may seem a contradiction. The more fearful areas in Carabanchel Public Housing may be a result of a more fragmented structure of the commonly used open spaces, the less visibility and the less connectivity of certain areas to the major circulation nodes. On the other hand Autofreie Mustersiedlung is not perceived fearful or insecure. The overall experience of safety may be related to closer social contacts and therefore possibly a higher degree of social control. Overall, the subjective experience of safety is the worse in the Spanish cases, even though for both projects public access is restricted. The inhabitants consider their block rather less safe compared to the surrounding areas, and also recall the most fearful places within the block, which has also the lowest visibility measures and the most fragmented structure of open spaces. Also, the feeling of insecurity was mentioned as a disadvantage in the open-ended questions.

Based on the data collected, the case studies with similar densities may show significant differences in terms of the experience of safety. Nevertheless, no clear correlation is apparent with the spatial layout, being a courtyard layout or free standing blocks. Some literature confirms the relative importance of socio-economic factors compared to the spatial features: Li and Rainwater's GIS based research (1999) shows an inconclusive relationship between compactness and crime rates, high density and multi-family development are not necessarily being associated with high crime rate, but socioeconomic status is. In addition, crimes could happen in any geographic locations, and different types of crime are apt to occur in different types of neighborhoods.

5.6.2.3. Healthiness of the residential environment

Based on the single question on the experience of healthiness of the apartments *(Chart 6., Q11)* the users of Ville Verdi experience their apartment the healthiest in terms of sunshine and ventilation, slightly healthier than Autofreie Mustersiedlung in which case some inhabitants considered their apartment somewhat unhealthy. Both Spanish cases are experienced less healthy, and there is a considerable difference between Carabanchel Public Housing and Pradolongo Social Housing, the former being experienced unhealthier. A possible interpretation is that nature centric projects with opened layout are experienced healthier, but only in the same context. Given the fact that there is less built-up area, more sunshine can access the apartments in the nature-centric projects, which may be reflected in the answers. The experience of healthiness may depend on other, for instance socio-economic and cultural ones that make difference between the Spanish and Austrian cases. Nevertheless, a layout that lets less sunshine in the apartments, inhabitants of Autofreie Mustersiedlung experience their apartment rather healthy, highlighting that it's possible to design apartments that are experienced healthy with the double courtyard typology. Nevertheless in Autofreie Mustersiedlung respondents mentioned density, the darkness of the flats as disadvantage. There are some details mentioned in relation to the healthiness of the apartments: inhabitants

of Ville Verdi point as a major disadvantage on the windiness of the site, some inhabitants of Carabanchel Public Housing mentioned as a main disadvantage the lack of light (despite its lower density compared to Autofreie). Figures on the healthiness of the apartments in the case of Pradolongo Social Housing may reflect that the original windows are hard to operate, affecting ventilation, as often mentioned in the survey.

If lower density is generally associated with the positive qualities of a healthier environment in terms of access to green space, ventilation and sunshine, it may be said that layouts with free-standing blocks provide a more advantageous experience of density if projects with similar density measures but different spatial layouts are compared. Nevertheless, a positive experience of healthiness can be reached with courtyard typologies as well, and the difference is not great.

5.6.2.4. Accessibility

Paradoxically the users of Autofreie Mustersiedlung find access to open (green) space in the block much better than those of Ville Verdi, despite the fact that the ratio of open green space is lower in the former project *(Chart 6., Q9).* An explanation is the fact that the users of Ville Verdi may access their apartment directly from the parking without passing through open-air common space, influencing significantly the perception of the accessibility of green. Also, even though there is less green, it's used more intensively in Autofreie Mustersiedlung, while open green spaces in Ville Verdi are planted with lawn. Despite the big difference in the open space and green space per dwelling figures, there is no big difference in the perception of the accessibility of green space, even for Carabanchel Public Housing, where the ratio of green space is extremely low. In spite of the low ratio of green in Carabanchel Public Housing, inhabitants were mostly satisfied with the proximity of green space than not. Though, the lack of green, leisure and socializing space appeared among the disadvantages of the block mentioned by the inhabitants. Despite the bad quality of green spaces within the block, residents of Pradolongo Social Housing are very satisfied with accessibility to green space, suggesting that easily accessible public green outside the perimeters of the block may be an acceptable substitute for semi-private and private green.

Concerning the access to parking: Ville Verdi, Carabanchel Public Housing and Pradolongo Social Housing show very similar figures in terms of accessibility of the parking space, despite the fact that several units in Carabanchel Public Housing have no direct indoor parking connection. In terms of access to parking, different spatial layouts can be equally satisfactory.

5.6.2.5. Aesthetics

In terms of the aesthetic stimulation, inhabitants of Ville Verdi find the architecture of the blocks the most stimulating *(Chart 6., Q10).* Autofreie Mustersiedlung is experienced somewhat duller. The Spanish case studies are experienced less stimulating, both the high-rise Pradolongo Social Housing and the low-rise Carabanchel Public Housing, though the former is experienced somewhat more stimulating. Responses from Carabanchel Public Housing show more variations though: some consider the design very stimulating, while some very dull. Based on the responses, the way people experience the aesthetics of their buildings is rather depending on architectural detailing than spatial configuration - both high and low rise typologies can be experienced stimulating or dull.

5.6.3. Composite score

To have an overall view of the experience of density a composite score has been created, which incorporates four variables used in the survey *(Table 5., Q2, Q4, Q10 and Q11).* The variables that have been chosen are those, which seem to correlate with the variables used to describe the distribution of density and spatial layout. These variables are:

-Privacy (high experienced privacy=5, low experienced privacy=1);
-Perception of safety relative to the surroundings (perceived unsafer than the environment =5, perceived safer=1);
-Aeshthetic stimulation (perceived aesthetically stimulating=5, perceived dull=1);
-Healthiness of the environment (perceived healthy=5, perceived unhealthy=1);

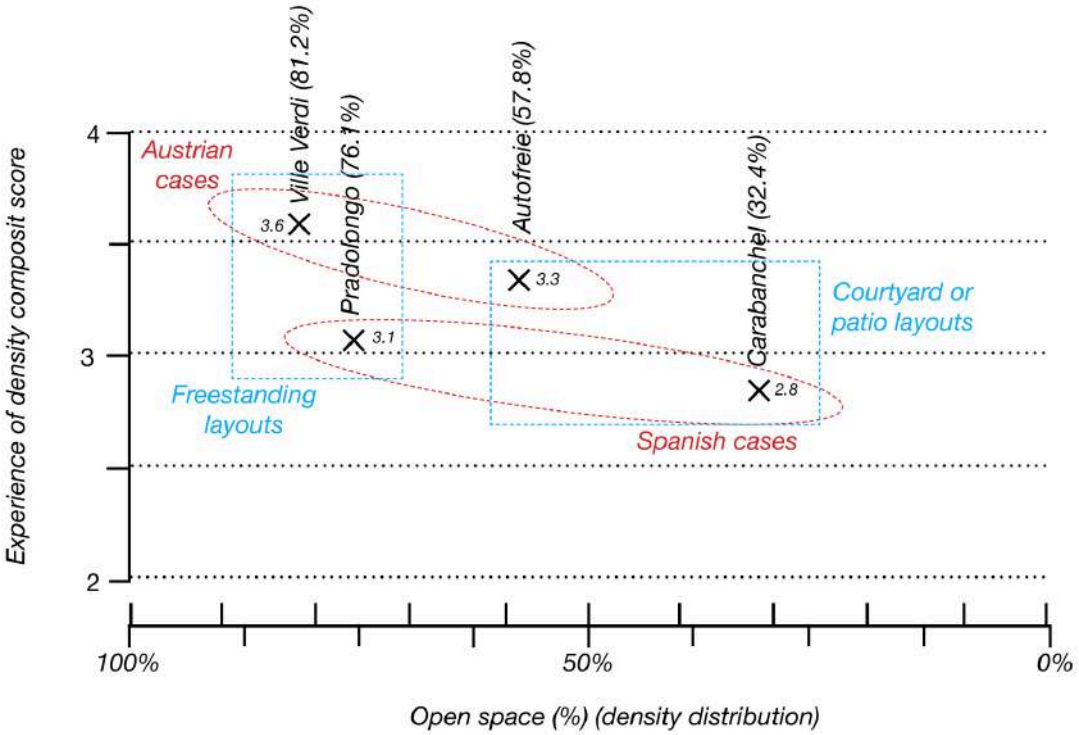


Chart 7. Experienced density composite scores and density distribution, source: own elaboration

Considerable difference can be seen between the case studies in Spain and Austria. As Ville Verdi and Pradolongo Social Housing are classified as freestanding/high-rise layouts and Autofreie Mustersiedlung and Carabanchel Public Housing as courtyard/low-rise, a difference can be seen between the two typologies in each context, since the free standing typologies are showing a higher value. The difference is small though (0.3 points on a scale of 5 in each context).

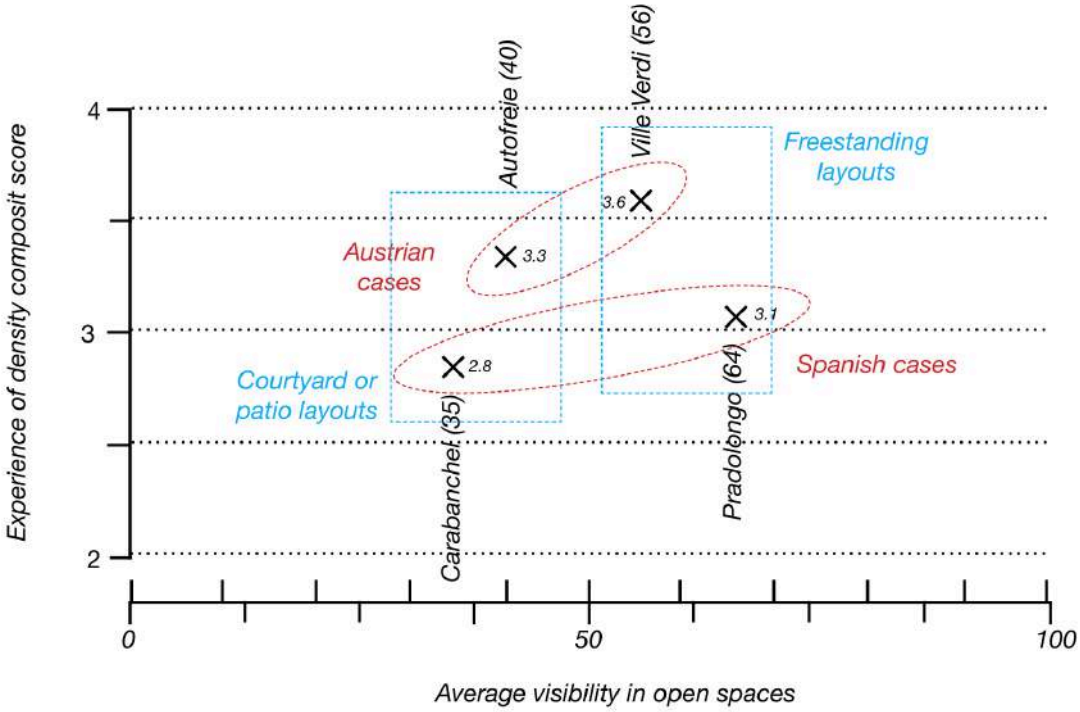


Chart 8. Experienced density composite scores and spatial configuration (visibility), source: own elaboration

Looking at the interrelation of spatial configuration and experienced density, similar patterns can be observed, reflecting the strong connection between the distribution of density and variables of spatial configuration. The freestanding typologies are showing a higher value in visibility and in the experienced density composite score as well, courtyard/patio typologies having lower visibility and experienced density score.

The composite score (4 variables) for the experience of density was calculated for each building type, taken as the average of the projects for each typology:

Typology	**Composite score of 4 variables**
Freestanding layout	3.38
Courtyard or patio layout	3.00

Table 5.3. Comparison of composite scores by typology

A difference between the freestanding/high-rise and courtyard/low-rise layouts is apparent, though close to the error margin.

5.6.4. Other remarks

Several reflections about the buildings in all the four cases (mainly disadvantages) are in connection with the bad quality of construction or other architectural details, specified in the construction documents' development phase of the projects rather than the spatial layout defined in the concept phase of the design process. In the case of high density projects commonly used spaces may not be appropriated by the inhabitants and therefore they do not have intentions to fix deficiencies in the construction by their own powers, supposedly opposed to low density living in individual units. The degradation of the built environment upon this path may influence the well-being and satisfaction of the residents and create aversion to high density living. The appropriation of commonly used spaces therefore needs to be in the scope of researches investigating the experience of high and low-density living. Also, while construction quality is not in relation with spatial configuration, based on the conversations and responses it may have a strong influence on the acceptability of high-density residential environments. Nonetheless, architectural detailing is not in the scope of any reviewed literature about the acceptability of high-density environments.

6. CONCLUSIONS

The issue of an ideal density is an ongoing debate with no consensus reached so far. According to the complexity of the issue, the debate is touching an extremely wide range of themes, and investigating a single aspect of density may hardly lead to a comprehensive verdict. An assumption of the thesis was that even though density is an important variable of urban form, assessing it without linking to the variable of spatial configuration is rendering density meaningless, and this link should be made to set up an adequate planning context. Therefore, the thesis has investigated how different spatial layouts (with different distribution of density and different spatial configurations) can lead to different experiences of social and spatial density, and to identify which design variables are the most relevant in the experience of urban density. Four research questions were raised to tackle this relationship: (1.) What are the effects of high density in the usage and perception of urban space? (2.) How do the effects vary depending on the patterns in its spatial layout? (3.) Is there a discrepancy between objective measures of density and the subjective perceived density? (4.) Is it possible to find and refine methodological tools to measure spatial qualities that are influencing how the users experience density?

The experience of density is abstract and therefore complicated to measure in itself. To overcome this problem, based on the literature review, different variables have been chosen, which are linked both to the perception of a certain density and to the organization of the built environment (perception of crime risk, healthiness of the environment, perception of social interactions, privacy, accessibility, aesthetics). By analyzing the variables above it was possible to - indirectly - draw a general picture of how inhabitants of residential projects may perceive in general the density of their close environment. Two variables have been chosen for the analysis of the spatial configurations: connectivity and visibility. Based on the literature review, the spatial analysis of the projects and the survey mapping the experienced density, the following answers could be drawn for the questions above.

1. What are the effects of high density in the usage and perception of urban space? - Density is related to the variables above, which is a result based on the literature review and confirmed in the survey responses (mentioning accessibility, healthiness, privacy, the quality of social relations with neighbors and security as factors that influence quality of life, locational choices and which are also connected to the density of the case studies).

2. How do the effects vary depending on the patterns in its spatial layout? - Same densities can be achieved with different layouts. The layout has effects on the visibility and connectivity measures, and moreover on the variations in density within the site - these being three measures which can be used for an objective description of spatial layouts. The distribution of density is in strong interrelation with the configurational features (connectivity and visibility) examined in the case studies. The higher rise typologies are operating with a less equally balanced distribution of density and have a higher visibility and connectivity, while lower rise, patio and courtyard layouts have a more even distribution of density, lower visibility and different patterns of permeability. Certain properties of the spatial layout may influence the experience of density: despite the similar overall densities, the cases show big variations in the experience of density. Nevertheless, the connection between spatial configuration, density distribution and the experience of density are not evident in most of the variable examined. Certain effects of density are weakly influenced by the spatial layout (healthiness and privacy are experienced higher in freestanding/high rise layouts, while the degree of social interaction is higher in the courtyard/low rise layouts), but in several cases other socio-

economic and cultural factors seem to be more relevant. Nonetheless, inter-cultural differences in the experience of density were not in the scope of the thesis. Other micro-scale (architectural) features (which are not related to spatial layout) seem to be just as influential in improving the acceptance of high density, and further research is needed to identify these features. Construction quality, architectural detailing, the appropriation of the commonly used structures can be mentioned as examples.

3. Is there a discrepancy between objective measures of density and the subjective perceived density? - There can be considerable differences in certain aspects in the experience of the density, while the objective density measures are similar: residential environments with similar density measures may show different perceived density; in this sense discrepancy between objective measures of density and subjective measures can be identified. Nevertheless, not all variables of the spatial environment linked to the perception of density show clear connection/correlation with spatial layout. The variables of experienced density that show connections of different degree with the spatial layout are privacy, perception of healthiness, accessibility, degree of interactions with neighbors. In other variables, such as in the number of people experienced or in the usage of open spaces for other purpose than circulation the link could not be justified.

4. Is it possible to find and refine methodological tools to measure spatial qualities that are influencing how the users experience density? - The thesis aimed to find a generalizable method for spatial analysis that connects density measures with spatial configuration on the scale of the urban block. Concerning the experience of density, most density related researches are investigating a single variable that is dependent of density. This may bring very refined results in that single aspect, but hard to apply in practice as other variables may be just as important and override an ideal solution from the point of view of that single aspect. The thesis therefore brought together and applied different variables from different authors in different contexts in order to have a more comprehensive assessment of the projects. The most useful methodological tools to measure spatial qualities that are influencing how users experience density have been the analysis of spatial configurations (connectivity and visibility) applied on a space-matrix, that could have been also used to measure density distribution, therefore links could have been established between the two variables.

A general observation is that the way inhabitants experience density is very context dependent and hardly generalizable. The different results from Austria and Spain show the importance of culture specific factors. The regulatory context needs to be adapted to these local specificities going beyond pure geometric definitions. It would be worth to explore the possibilities of including the configurational aspects of the layout in the current set of soft regulatory tools, such as giving recommendations for designers or including it in the jury and selection process of architectural projects. On the macro scale as well, compaction policies need to be adapted to the very local context in order to tackle the singular factors that are behind concentration and de-concentration processes. In terms of practice, a major challenge is to reach a sustainable political consensus in order to implement densification objectives, involving making high density acceptable for actors with preferences for low-density developments. For this more research is needed to map the various architectural features of residential environments that influence the experience of density and these features need to be incorporated in the regulatory context.

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8. ANNEXES

8.1. Photos

Carabanchel Public Housing

Image 7.: Northern view (source: own caption)

Image 8.: Southeastern view (source: own caption)

Carabanchel Public Housing

Image 9.: Southern view (source: own caption)

Image 10.: Western view (source: own caption)

Carabanchel Public Housing

Image 11.: Public Plaza (source: own caption)

Image 12.: Alleys (source: own caption)

Autofreie Mustersiedlung

Image 13.: Northern view (source: own caption)

Image 14.: Eastern view (source: own caption)

Autofreie Mustersiedlung

Image 15.: Southern view (source: own caption)

Image 16.: Western view (source: own caption)

Autofreie Mustersiedlung

Image 17.: Inner courtyard (source: own caption)

Image 18.: Space between the blocks (source: own caption)

Pradolongo Social Housing

Image 19.: Northern view (source: own caption)

Image 20.: Eastern view (source: own caption)

Pradolongo Social Housing

Image 21.: Southern view (source: own caption)

Image 22.: Western view (source: own caption)

Pradolongo Social Housing

Image 23.: In-between space (source: own caption)

Image 24.: Space between the blocks (source: own caption)

Ville Verdi

Image 25.: Northwestern view (source: own caption)

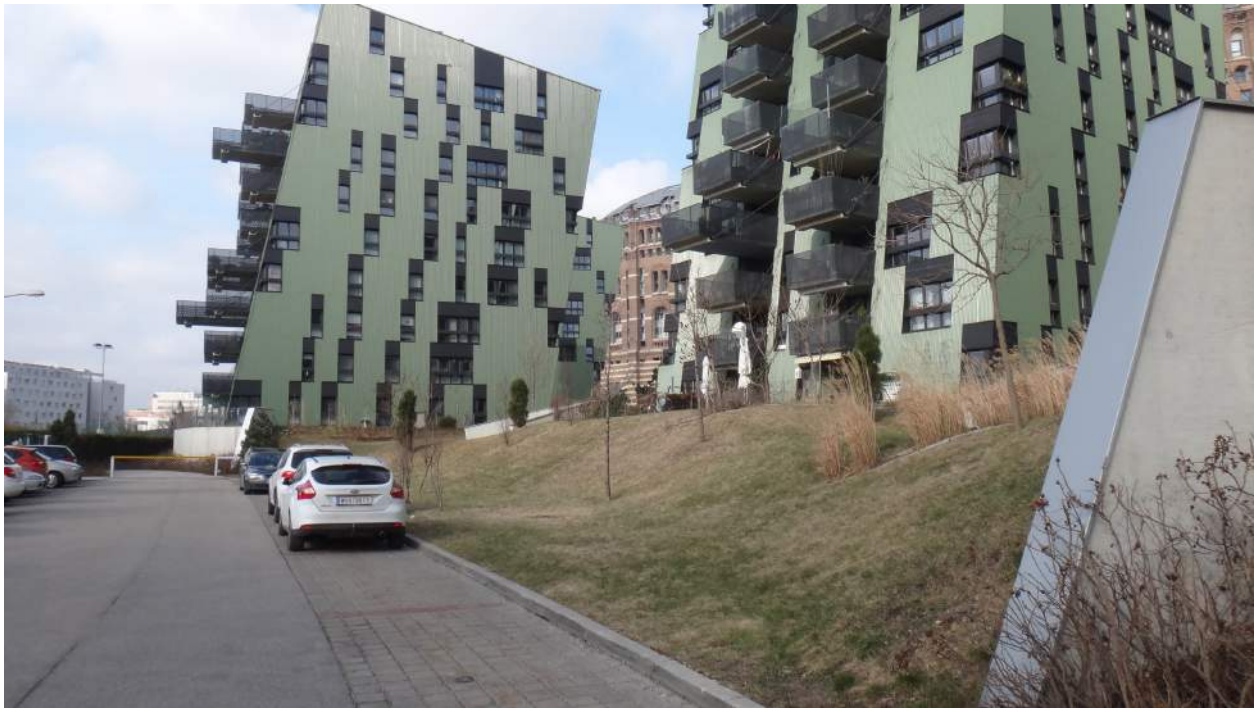

Image 26.: Southeastern view (source: own caption)

Ville Verdi

Image 27.: Common open air space (source: own caption)

Image 28.: Western view (source: own caption)

Ville Verdi

Image 29.: Common open-air space (source: own caption)

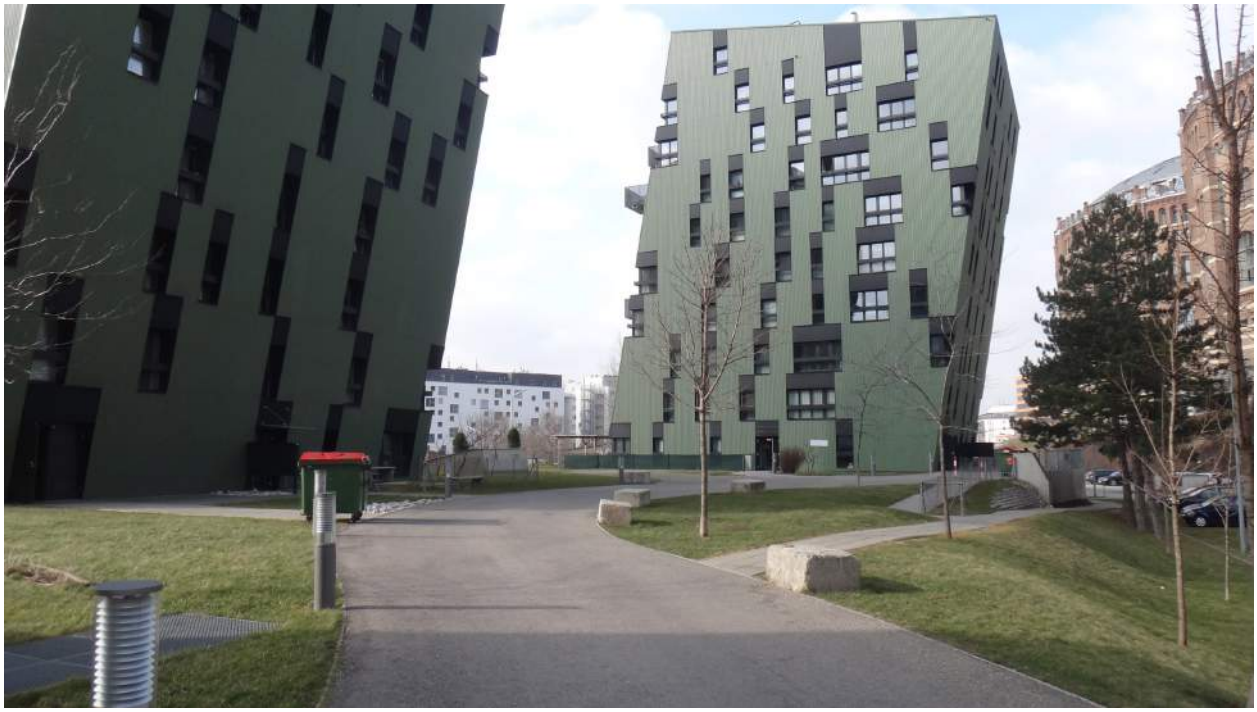

Image 30.: Space between the blocks (source: own caption)

8.2 Spatial Analysis

8.2.1. Density distribution graphs

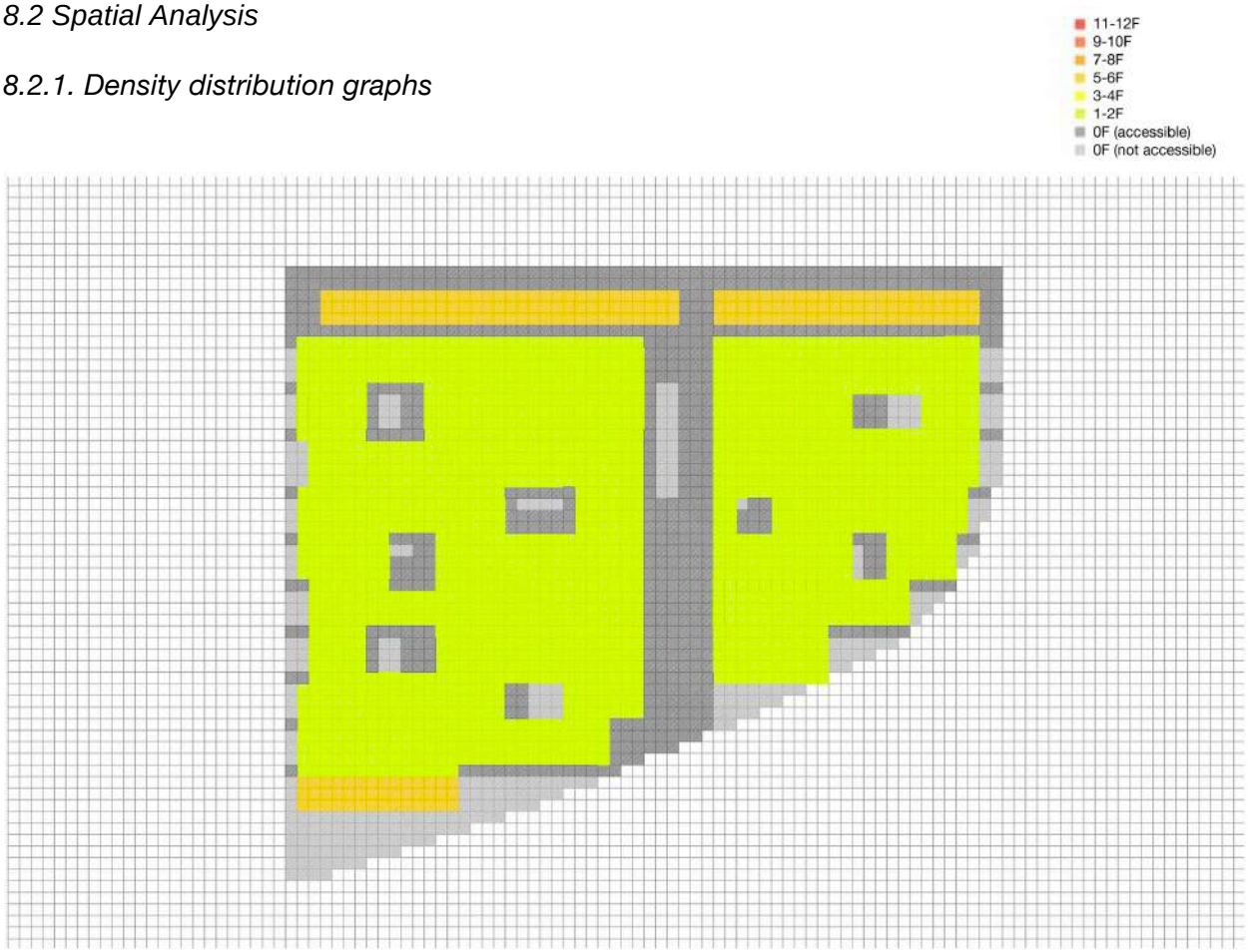

Figure 25.: Carabanchel Public Housing, density distribution, source: own elaboration

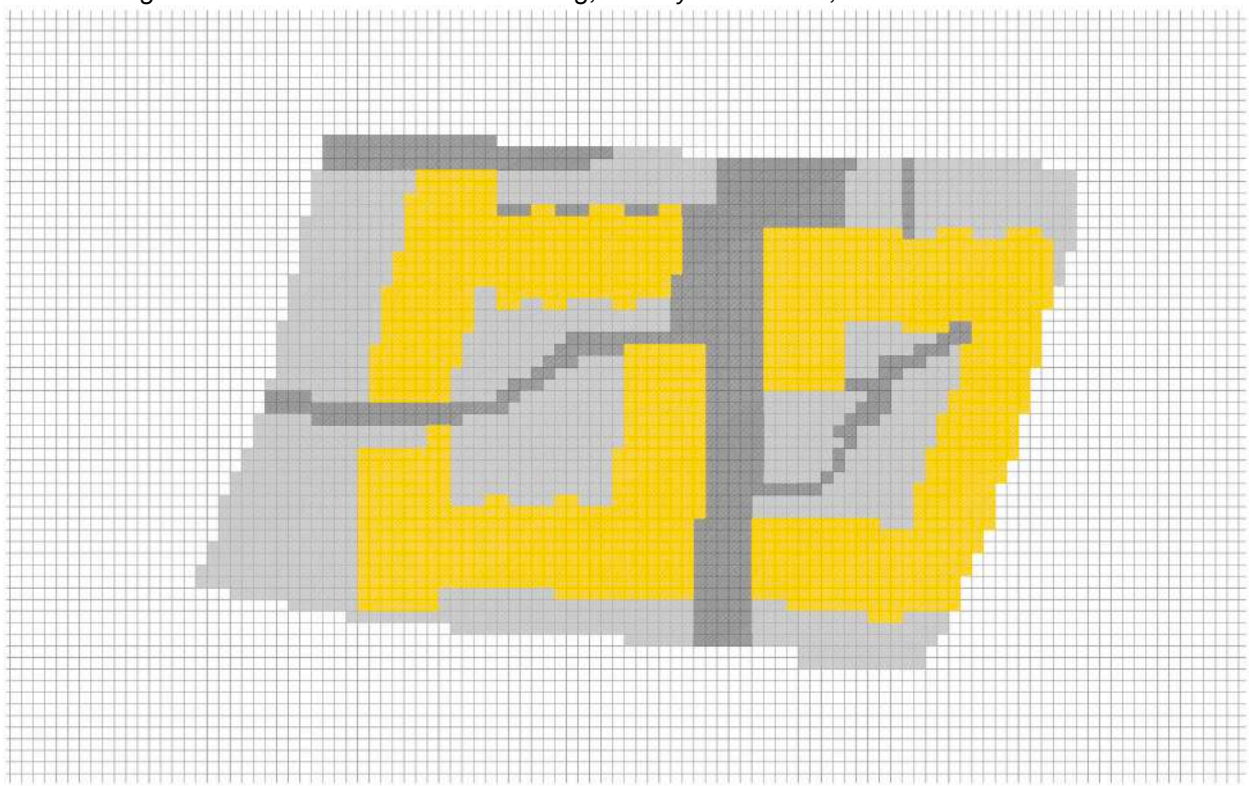

Figure 26.: Autofreie Mustersiedlung, density distribution, source: own elaboration

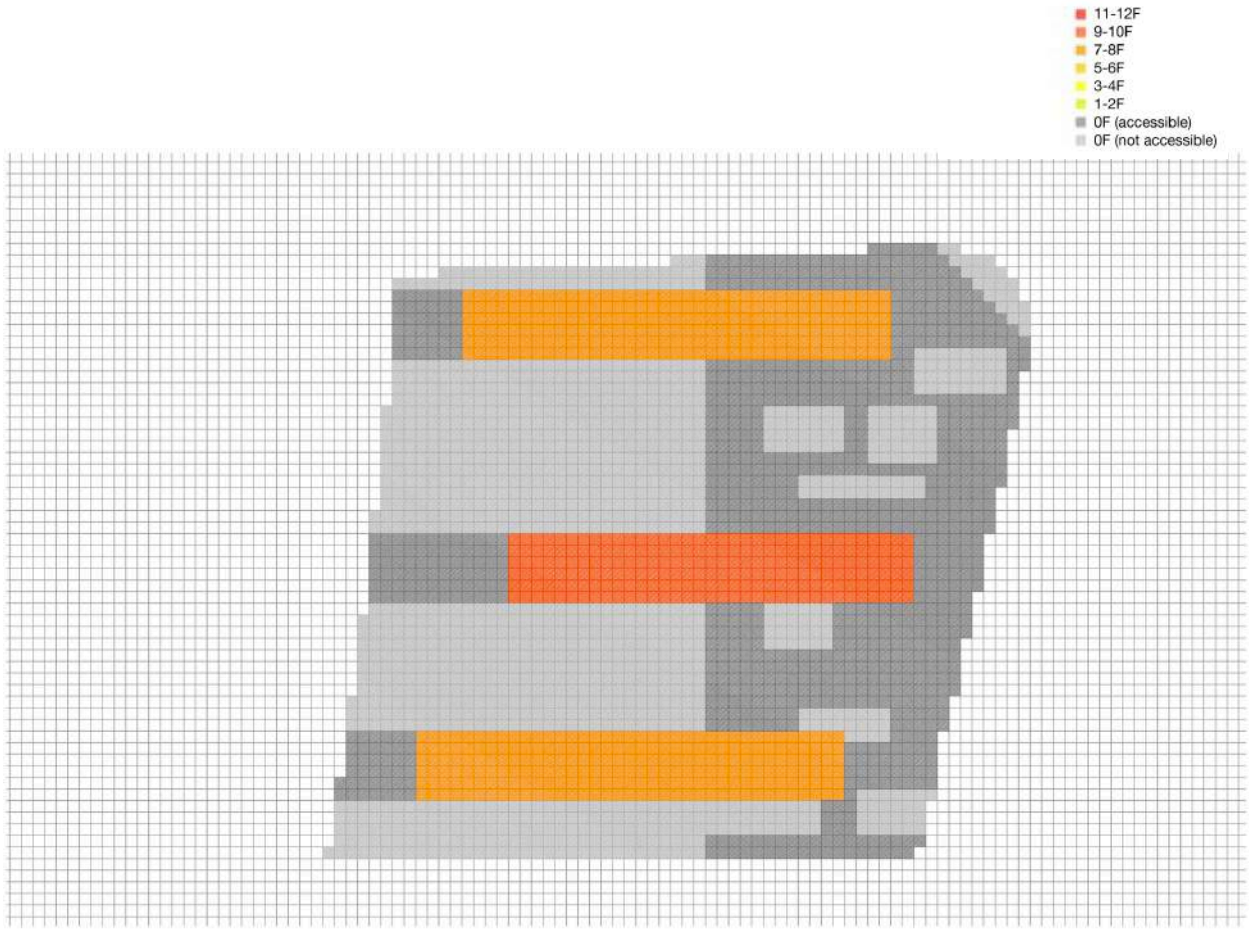

Figure 27.: Pradolongo Social Housing, density distribution, source: own elaboration

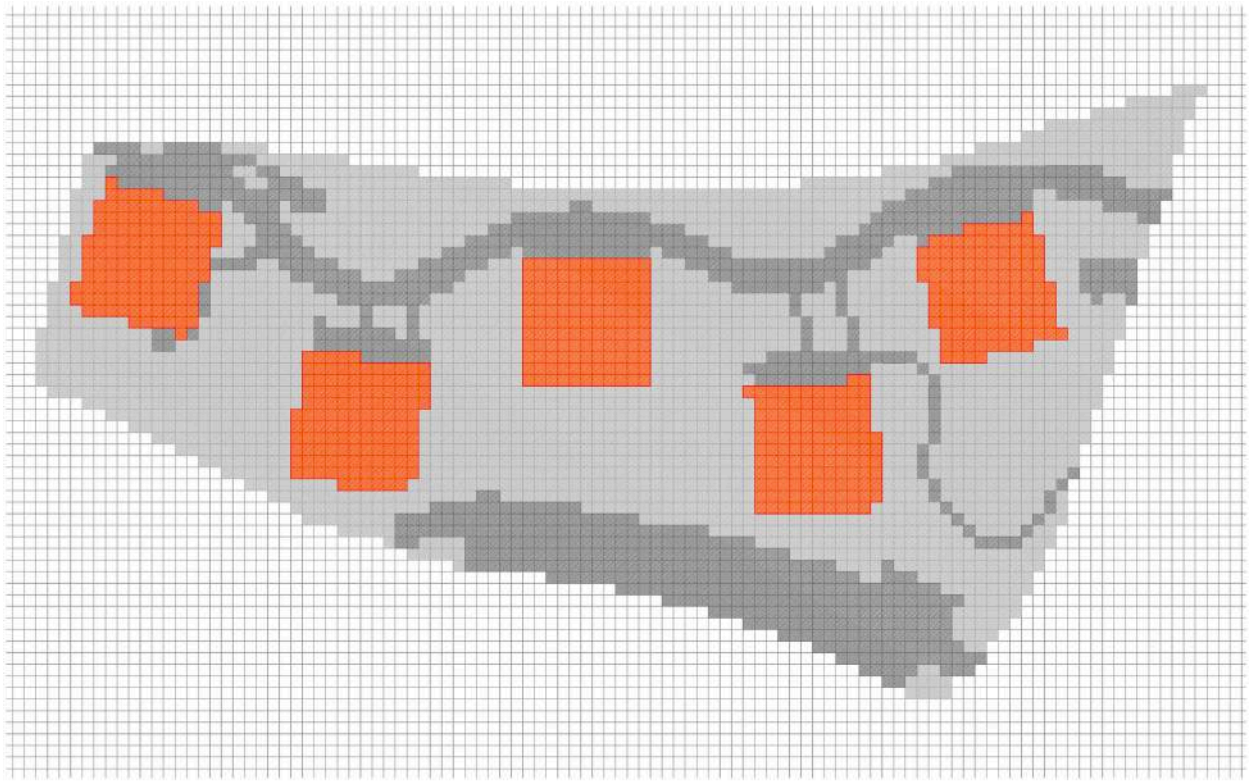

Figure 28.: Ville Verdi, density distribution, source: own elaboration

8.2.2. Spatial configuration analysis

	Carabanchel Public Housing	**Autofreie Mustersiedlung**	**Pradolongo Social Housing**	**Ville Verdi**
Number of nodes (by the number of links)	36 nodes with 3 links: 31 nodes with 4 links: 5 average number of links: 3.14	23 (nodes with 2 links: 4 nodes with 3 links: 17 nodes with 4 links: 2 average number of links: 2.91	7 nodes with 3 links: 5 nodes with 4 links: 2 3.28	9 nodes with 3 links: 9) average number of links: 3
Number of exits from the project site	20	6	2	4
Average number of units connected to each in-door entrance	1.6	34.3	48	34
Total path length in open space (number of fields crossed)	1160	856	470	398
Average path length to exit	27	41	83	57

Table 4. Results of the analysis of the spatial configuration graphs

8.3. Survey design and results

8.3.1. Variables and questions

Variable	Item	Question
Relation between users	Crowding	Q1 - Do you experience the amount of people on the public space positive or negative?
	Visual exposure	Q2 - In what degree are you satisfied with your visual privacy inside your apartment?
	Interactions	Q3 - In what degree do you interact with your neighbors?
	Safety	Q4 - To which degree do you think that your block and its environment are safer than the surrounding neighborhood?
Relation between user and environment	External access (transport)	Q5 - What is the major mode of transport you use to go to work?
		Q6 - What is the major mode of transport you use to go to shop?
		Q7 - Do you find this distance between the public transportation stop and your apartment confortable?
	Open space	Q9 - Do you find the access to open public (green) space in the close proximity of your apartment satisfying?
		Q13 - How often do you use open space in the block for other purposes than circulation (such as sitting, playing, socializing, etc.)?
	Healthiness	Q11 - Do you find your environment healthy in terms of sunshine and ventilation in your apartment?
	Stimulation	Q10 - Do you find the architecture of the block rather dull or stimulating?
	Uncontrolled spaces	Q12 - Can you recall fearful areas in the block and its environment?
Other		Q14 - Which are the main advantages of the block you live in?
		Q15 - Which are the main disadvantages of the block you live in?
Demographic and socio-economic background	Age	Q17 - What is your age?
	Gender	Q16 - What is your gender?
	Employment	Q18 - Are you currently…
Residential situation	Date of moving	Q19 - Which year did you move in your apartment?
	Apartment size	Q20 - What is the size of your apartment?

Table 5. Survey design: variables, items, and questions

8.3.2. Form

universität wien

SURVEY ON THE QUALITY OF YOUR RESIDENTAL ENVIRONMENT

This survey tries to improve high-density residential area like your neighborhood, and its results may be useful for that purpose. As a researcher of University of Vienna, I guarantee that the answers would be anonymous. To response the survey will take you around 5 minutes. Please answer it on paper and drop it at …… or complete the survey online using the following URL: ……

Thank you very much for your collaboration.

Balint Halasz

Master Student in Urban Studies

1. Do you think that the amount of people in the public space of your block is…?

- ☐ Very high
- ☐ Somewhat high
- ☐ Neutral
- ☐ Somewhat low
- ☐ Very low

2. In what degree are you satisfied with your visual privacy inside your apartment?

- ☐ Very high
- ☐ Somewhat high
- ☐ Neutral
- ☐ Somewhat low
- ☐ Very low

3. In what degree do you interact with your neighbors?

- ☐ Very high degree
- ☐ Somewhat high degree
- ☐ Neutral
- ☐ Somewhat low degree
- ☐ Very low degree

4. To which degree do you think that your block and its environment are safer than the surrounding neighborhood?

- ☐ Very high degree
- ☐ Somewhat high degree
- ☐ Neutral
- ☐ Somewhat low degree
- ☐ Very low degree

5. What is the major mode of transport you use to go to work?

- ☐ Walking
- ☐ Car
- ☐ Bicycle
- ☐ Bus
- ☐ Metro
- ☐ Train
- ☐ Other

6. What is the major mode of transport you use to go to shop?

- ☐ Walking
- ☐ Car
- ☐ Bicycle
- ☐ Bus
- ☐ Metro
- ☐ Train
- ☐ Other

7. Do you find this distance between the public transportation stop and your apartment confortable?

- ☐ Very comfortable
- ☐ Somewhat comfortable
- ☐ Neutral
- ☐ Somewhat uncomfortable
- ☐ Very uncomfortable

8. Do you find this distance between the parking and your apartment confortable?

- ☐ Very comfortable
- ☐ Somewhat comfortable
- ☐ Neutral
- ☐ Somewhat uncomfortable
- ☐ Very uncomfortable

9. Do you find the distance to open public (green) space in the close proximity of your apartment satisfying?

- ☐ Very satisfying
- ☐ Somewhat satisfying
- ☐ Neutral
- ☐ Somewhat unsatisfying
- ☐ Very unsatisfying

10. Do you find the architecture of the block rather dull or stimulating?

- ☐ Very stimulating
- ☐ Somewhat stimulating
- ☐ Neutral
- ☐ Somewhat dull
- ☐ Very dull

11. In which degree do you find your apartment healthy in terms of sunshine and ventilation?

- ☐ Very healthy
- ☐ Somewhat healthy
- ☐ Neutral
- ☐ Somewhat unhealthy
- ☐ Very unhealthy

12. In what degree do you recall fearful areas in the block and its environment?

- ☐ Very high
- ☐ Somewhat high
- ☐ Neutral
- ☐ Somewhat low
- ☐ Very low

13. How often do you use open space in the block for other purposes than circulation (such as sitting, playing, socializing, etc.)?

- ☐ Daily
- ☐ Few times a week
- ☐ Few times a month
- ☐ Few times a year
- ☐ More rare or never

14. Which are the main advantages of the block you live in?

15. Which are the main disadvantages of the block you live in?

16. What is your gender?

- ☐ Male
- ☐ Female

17. What is your age?

- ☐ 65 and over
- ☐ 50-64
- ☐ 30-49
- ☐ 18-29
- ☐ 0-17

18. Are you currently…

- ☐ Employed
- ☐ Self-employed
- ☐ Unemployed
- ☐ Student
- ☐ Retired
- ☐ Unable to work
- ☐ Other

19. Which year did you move in your apartment?

- ☐ 5 years or more
- ☐ Between 2 years to less than 5 years
- ☐ Between 6 months to less than 2 years
- ☐ Less than 6 months

20. What is the size of your apartment (in square meters)?

- ☐ 120 or more
- ☐ 100 to under 120
- ☐ 80 to under 100
- ☐ 60 to under 80
- ☐ 40 to under 60
- ☐ under 40

ERKLÄRUNG

Hiermit versichere ich,

-dass die ich die vorliegende Masterarbeit selbstständig verfasst, andere als die angegebenen Quellen und Hilfsmittel nicht benutzt und mich auch sonst keiner unerlaubter Hilfe bedient habe,

-dass ich dieses Masterarbeitsthema bisher weder im In-noch im Ausland in irgendeiner Form als Prüfungsarbeit vorgelegt habe

- und dass diese Arbeit mit der vom Begutachter beurteilen Arbeit vollständig übereinstimmt.

Wien, 31.08.2015 Balint Halasz

CURRICULUM VITAE

Personal Information

First name	Balint
Surname	Halasz

Education

Dates	2001-2010
Title of qualification awarded	masters in architecture and engineering
Name of organisation providing education	Budapest University of Technology and Economics

Dates	2005-2006
Title of qualification awarded	exchange studies, MIRA program
Name of organisation providing education	Ecole Nationale Superieure d'Architecture de Lyon

Dates	1995-2001
Title of qualification awarded	baccalaureate
Name and type of organisation providing education	Gödöllői Református Líceum