# ANALYSIS OF THE SPECTRE OF URBAN DENSITY FROM THE PERSPECTIVE OF COMPACTNESS OF FORMS – A RESPONSE TO A NEW URBAN VULNERABILITY

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**Abstract**

The concepts of *density* and *urban morphology* are today at the centre of debates on architecture and urban planning. The concept of density provides a solution to the issue of urban sprawl and, consequently, offers a way of rethinking sustainable urban and rural development. The densification of urban centres makes it possible to reduce a vulnerability related to the excessive use of suburban areas. However, densification is not a "turnkey" solution. Numerous criteria relating to its use are poorly understood. As numerous contemporary experiences have demonstrated, urban densification exposes space systems to new, unknown forms of vulnerability.

First, we will define the concept of *vulnerability,* specifically that of *urban vulnerability,* as well as related concepts, such as those of *risk*, *hazard* and *challenges.* Secondly, we will pinpoint forms of vulnerability inherent in the over-densification paradigm: this will involve determining the specific hazards, challenges and risks of this space system. Thirdly, we will demonstrate how the concept of *compactness* makes it possible to review at the different urban levels the densification processes of territories and urban areas. Finally, we will propose a tool for the optimisation of compact urban morphologies for use in countering the related hazards and risks.

## 1. Introduction

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**2. Vulnerability and its related concepts of risks, hazards and challenges**

The concept of vulnerability has as its etymology the Latin words “vulnera(re)”, “vulnerarius”, which refer to injury or sensitivity to attacks. In the 1950s, vulnerability emerged in the field of physics and, more widely, in the field of hard sciences. This concept allows us to rethink the consequences of a disaster by refocusing them on the physical characteristics of the disruption and on the impact process. Between 1960 and 1980, vulnerability was introduced into human sciences. It concerns the ability of societies to adapt to hazards or to deal with a crisis. During the 1990s, the concept took on a new meaning focused on the interdependency, within a society, of the physical, biological and human processes. In addition, it should be remembered that the disruptions creating vulnerability can be spread over time and across the space system (Dauphiné & Provitolo, 2007). Applied to the field of urban planning, urban vulnerability is defined by Mr Lussault as “the likelihood of a city experiencing a major incident of some kind. A major incident is understood to mean an event which causes long-term disruption to the urban system and its operation” (Lussault, 2010). The vulnerability of urban systems is determined by the technological, economic, financial, political and cultural development. The development of societies and the forms of vulnerability are therefore closely linked.

Whether technological, sociological or natural*, risk* refers to the threat facing space systems. To fully understand this concept, it is relevant to define the concepts of hazards and major challenges. A hazard is defined as a natural event which represents a threat and is characterised by its intensity and a hypothetical, flexible time span. White and Haas specify that (natural) hazards do not necessarily lead to disasters. They materialize only where society is inadequately or insufficiently adapted (Reghezza, 2011). If a hazard characterises “a physical, natural and uncontrollable phenomenon, independently of its potential effects on the environment and human activities”, it differs from a disaster which can be defined by the break that it introduces in “a trajectory, in the reproduction of a system” which initiates “the implementation of a new system’ (Brunet, Ferras, & Théry, 1993). According to P. Gala Serra, a hazard “only becomes a risk if there are challenges” (Gala Serra, 2007). The major challenge of a territory is the population. It is accompanied by other challenges, which are less important taken separately, but which, when considered within the framework of a network, are crucially important for territories and the population. They can be grouped together under the concepts of environment, related physical and immaterial property. F. Leurent et al. classify the major challenges of territories in six specific areas: “demography, lifestyles, organisational structures and management processes, spatial forms, the ecological environment and the technical forms combining organisational techniques and technological production techniques” (Leurent, Aw, & Coulombel, 2007). Risk can thus be defined as the threat created by a hazard involving a territory’s minor or major challenges. It generates far-reaching socio-economic, environmental and political disruptions. Although it is impossible to eliminate risk, the objective of this study is to propose a new risk management method and, consequently, to cushion its impact on the space system, thereby reducing vulnerability.

The concept of territorial vulnerability has a negative connotation: it embodies the image of a territory facing difficulties. Anthropogenic elements are likely, for example following a temporary exposure, to spread occasional disruptions and even long-term failures across a system as a whole. An analysis of vulnerability highlights the sensitivity of a space faced with one or more

elements of a fragile territory. This diagnostic phase facilitates, in the medium term, control and risk management actions before the confrontation: by identifying the major challenges of a territory and prioritising them it is possible to prevent their failures. Territorial vulnerability to a major challenge is transmitted by dependency, thereby persisting and evolving. (D'Ercole, Thouret, Dollfus, & Asté, 1994). In a context of territorial dependency, such transmission seems inevitable within each territory. We can therefore refer to the presence of "a real vulnerability transmission mechanism" (D'Ercole & Metzger, 2009).

**3. Does the risk arising from densification represent the emergence of a new urban vulnerability?**

Urban densification, in contrast to urban sprawl, creates savings of energy and land resources (heating, transport, equipment, etc.) and space (green spaces, agricultural land, forests, etc.). It is based on two modes of realisation: one is reasoned and considered, while the other is random and spontaneous. The first limits the ecological footprint while increasing residual outdoor spaces and the feeling of urbanism. This new urban planning paradigm is essential in order to generate or reinforce a more harmonious territorial development in accordance with specific urban and rural characteristics. Nevertheless, the implementation of urban densification processes is painstaking: the multidisciplinarity of approaches and the diversity of the parameters to be taken into consideration in order to establish an urban densification plan renders its application at the different levels (global and local) of the territory complex and delicate. In addition, the increase in the urban population (by 2030 more than 60% of the world's population will live in cities) (Fiksel, 2006) suggests that it will be necessary to make cites that are already extremely dense even denser. The second, a consequence of the recent economic growth of certain countries in South Asia, is apparent either in the anarchical construction of towers in new over-dense districts or in the unregulated densification of "favelas" or shanty towns. In both cases, the densification leads irremediably to over-densification, unusual extreme density, in the short or long term. It is difficult to measure over-densification, but it converges towards a vulnerable system. The boundary between sustainable densification and over-densification is narrow and depends on many context-related factors (urban planning, geographical, sociological and economic factors). Sustainable, considered densification helps to improve the quality of life via, in addition, greater access to green spaces, urban centres, the multifunctionality of neighbourhoods, etc. Nevertheless, indulging in extremes of densification and therefore making a city over-dense tends to undermine urban mobility (overcrowded public transport, traffic congestion, etc.), reduce residual areas (green space, public areas, road width, etc.), lead to increasingly taller buildings, blocking out sunlight, among other things, and increasing urban noise pollution, etc.

Analysing the points of vulnerability related to the over-densification of cities and therefore targeting the hazards and challenges of this phenomenon enables us to assess the risks. This analysis will enable us to propose a proactive strategic tool.

The vulnerability of over-dense cities is linked to specific hazards and challenges. Over-dense cities are subject to endogenous hazards: they are more vulnerable than traditional cities to natural disasters (storms, hurricanes, earthquakes). They are also weakened by exogenous hazards: they are faced with various crises (economic, environmental and social). They are partly the result of the demographic explosion of certain territories, the urban exodus and the wish to curb urban sprawl. The three main pillars of sustainable development – the economy, the environment and the population – grouped together in the concept of the living environment, characterise the challenges. The undermining of these challenges creates specific risks such as the reduction of mobility, accessibility, the quality of well-being, green spaces as well as the attractiveness of the city, combined with increased pollution and social oppression. Is it therefore possible to develop a tool to optimise compact urban morphologies in order to manage these?

**4. Is the concept of compactness a qualitative response?**

Can the concept of compactness and the study of compact urban morphologies resolve the risks of over-dense cities? Densification and compaction are two separate concepts. The success of their application arises nevertheless from a consistent simultaneous study as part of a series of interdependent concepts (mobility, accessibility, centrality, multi-functionalities, etc.). As Da Cunha and Kaiser note: “Making the city more compact makes it possible to influence at the same time the density, urban forms, activity groupings and the environmental impact of the urban metabolism” (Da Cunha & Kaiser, 2009). Compactness thus provides a response to the twofold problem of densification and the reduction of energy losses. It is important to define compactness, often compared with density, by taking account of the different urban scales: “Compactness is a model of which density is only one indicator.” (Pouyanne, 2004).

The concept of compactness can be justified at each territorial level and embodies the concept of form: urban morphologies of neighbourhoods, blocks and built-up areas. On a global scale, the concept refers to two separate definitions. The first, which we call urban porosity, corresponds to the porosity factor in the area of physics summarised as the value obtained by the ratio of the containing volume to the volume contained (Tallet & al., 2009). The more the degree of porosity decreases, the more the residual areas decrease. Based on the usual topology of space and planning, the second concept of *urban compactness* defines a compact city as a contained area which is not necessarily contiguous. A high degree of functional diversity helps to reduce the distances to be travelled (Levy J., 2008) (Da Cunha & Kaiser, 2009). This reveals two compact urban morphologies (Bonin & Tomasoni, 2013). First, the concentric city is inherently subject to linkage and is therefore continuous. This dense structure implies a modest size. Secondly, the polycentric city, developing several inter-connections, is structured around a common mobility plan. It favours multi-functionality and relations with nature. The “qualitative compactness” reference model defined by Charmes and Souami, (Charmes & Souami, 2009) reflects a wish to resolve urban vulnerability in a practical manner by focusing the approach on a programme based on a holistic plan which evolves according to society’s needs. This includes: mobility (increased public transport together with functional diversity and increased accessibility), the creation of compact, communal accommodation, an increase in public or semi-public green spaces. At sub-local level, the parameters of the compactness factor are easier to develop: they are considerably smaller and exclusively geometrical. Studying the compactness of the form of blocks of buildings, called the *form factor*, makes it possible to have an impact on the planned design of buildings and the heart of the urban block. Studying this from a compact form encourages a high-quality development and green potential. In the same way as urban porosity, the compactness of the block may also be considered from the point of view of porosity. From the perspective of a formal approach to built-up areas, two factors of compactness stand out. The first, which we call *energy compactness*, takes account of the building mass and is dependent on the construction size, while the second *constructed compactness* considers the built-up area. Their values, resulting from strictly geometric parameters, help to optimise the built-up area according to its form.

In order to make the various territorial levels more compact, we will put in place a morphological optimisation tool. This morphological study will provide a reasoned and qualitative compactness perspective.

**5. Development of a tool to optimise compact morphologies**

Creating a tool to optimise compact urban forms will make it possible to simulate, objectify and validate compact morphologies of built-up areas with a high population density in accordance with predetermined parameters and objectives. Consequently, we will be able to respond positively to the need for sustainable densification. Identifying and analysing the maximum urban porosity and porosity of blocks of buildings in a defined context will enable urban planners and architects, on the one hand, to implement sustainable projects that pay due heed to the

economic, environmental and social challenges and, on the other hand, to avoid increasing urban vulnerability by over-densification. These morphologies can be considered as a “response to the issue of constructing a more compact and eco-friendly city” (Da Cunha & Kaiser, 2009).

However, compactness must be applied taking account of its interdependency with the other concepts, in particular density, but also intensity, centrality, urban planning, multi-functionality and accessibility, otherwise it will no longer be effective. In order to respond as broadly as possible to the problem, we must assess the secondary constraints. These are inventoried as direct and indirect external functions of the tool. They include, among others, the constraints relating to the context, the different issues and the feasibility of the programme. Specifications defining these principal and secondary functions will also make it possible to define the constraints, criteria and the related flexibility levels and values. Using the tool will make it possible to develop a project that responds to all these functions while respecting a predetermined density. The tool structured on the basis of an iterative system includes volume encoding, sizing, distortions and assembling. At each stage, the filters of the optimisation tool will objectify quantified responses according to the ranges of values determined according to specific criteria. The iterative structure of the tool will facilitate the adaptation of the project throughout the design phase in order to develop optimised morphologies that respond to the challenges.

**6. Conclusion**

In the past, densification was a tool used to help improve the living environment. Today, it has become fairly controversial, with criticism focused on the shortcomings of an evolutionary cyclical approach. Nevertheless, studying formal compactness could, on the one hand, remedy the deficiencies of this paradigm and, on the other hand, propose new responses to urban vulnerability. Is this factor an additional and complementary source of urban resilience?

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