

HI RISE! I CAN SEE YOU

PLANNING AND VISIBILITY ASSESSMENT OF HIGH BUILDING DEVELOPMENT IN ROTTERDAM

12.1 INTRODUCTION

Western European cities like London, Paris, Rotterdam and Frankfurt am Main have seen impressive high building developments over the past two decades. This has led them to develop policies for regulating the planning and construction of tall buildings, high-rise buildings and skyscrapers within their territory. So far, these high building developments and policies have received little attention from the academic community. This chapter elaborates a framework for analysing high building development and the visual impact of high buildings on the surrounding landscape with the city of Rotterdam as a Western European showcase. It presents a systematic approach for analysing high building development in terms of architectural height, year of completion, location and functional use, for use in the comparison of existing buildings with the urban policies that are in place. Comprehensive GISc-based viewsheds were used to analyse the visibility of the high buildings, factoring in both meteorological circumstances and the vertical area of the buildings. The showcase city of Rotterdam demonstrates that a considerable distance exists between the vision and reality. The city struggles to deliver a consistent and integrated policy for high-building urban areas, while the high building developments themselves seem to be ruled by a remarkable internal logic that is not fully recognised in policymaking.

The impact of tall buildings, high-rises and skyscrapers on neighbourhoods, urban districts and cities is widely acknowledged by architects, urban planners, politicians and developers all

over the world. The planning and construction of high buildings is not without controversy. Tall buildings, high-rises and skyscrapers have the ability, like no other building typology, to polarise the public debate on architecture and the built environment, to evoke a sense of urban identity or alienation, to represent the economic growth or decline of a city, and even to become the symbolic target in armed conflicts or acts of terrorism.

Concerns about the appropriateness of high buildings in the (urban) environment, the (iconic) quality of their architecture, and their impact on local real estate markets is increasingly reflected in municipal and metropolitan policymaking. Prominent cities with a longstanding tradition of urban management, building regulations and zoning plans seem to feel the need for additional instruments to control the development of what is described by McNeill as “an extremely complex spatial phenomenon” (McNeill, 2005). There is a tendency in the scientific literature, however, “... to neglect the substantial impact of skyscrapers on urban life. Yet the significance of these buildings — in terms of height, levels of human occupancy, aesthetic impact and popular representation and use — is in need of careful geographical interpretation” (McNeill, 2005).

There are many terms that are used to address high buildings: tall buildings, high-rise buildings and skyscrapers. Each of those terms has a specific means or connotation, depending on the context or the framework in which it is used. To avoid unnecessary confusion this chapter uses consistently the term high buildings.

The chapter starts with placing the developments in Rotterdam in its international context: Western Europe. It then describes the development of high buildings in Rotterdam and the city’s successive high building policies. It describes in detail the analysis of the visual impact of Rotterdam’s buildings on the surrounding territory by means of GISc (Geographic Information Science), before drawing conclusions on the same.

12.2 HIGH BUILDING DEVELOPMENT IN WESTERN EUROPE

Within this context, this chapter presents an original approach for analysing clusters of high buildings. Rotterdam serves as a showcase. The city represents a prominent European high building city that has a mature (already revised) high building policy in place. Rotterdam is part of the Emporis Top 20 of European high building cities (Emporis, 2009), as one of only four Western European cities that made it onto this list: London, Paris, Rotterdam and Frankfurt am Main. The leading position of the city of Rotterdam is furthermore underscored by DEGW’s report on London’s Skyline, Views and High Buildings (DEGW, 2002) commissioned by the Greater London Authority. The London policy document uses the same four European

cities to compare established European practices of high buildings policymaking: London, Paris, Frankfurt and Rotterdam.

There are many other cities worldwide with a substantial number of high buildings. Those in Europe, however, make up a special case. The development of tall buildings, high-rise buildings and skyscrapers in Europe is embedded in an environment very different to that of America, Australia, Asia or the Arabian Peninsula. The European cities and their surrounding cultural landscapes have evolved gradually over centuries, if not millennia. Their built heritage, when not ravaged by war, is substantial. The relatively slow pace of development, due to a moderate economic growth rate, provide the time that is necessary for careful consideration. The well-developed practice of local democracy allows for the involvement of many political parties, stakeholders and pressure groups in the decision-making process. Among them are organisations and individuals that place strong emphasis on the importance of preserving the value and quality of the built heritage that was put in place by previous generations.

High buildings have been controversial in the Netherlands for years, if not decades. In the 1960s and 1970s, large modernist residential estates were planned and built in the outskirts of many Dutch cities and towns. These buildings had a negative impact on the public opinion. It was only after the emergence of a new type of high building development in the inner cities and suburban centres in the early 1990s that this image started to change for the better, not just in Holland but also throughout much of Europe (Sudjic, 2005). Even now, high buildings evoke emotions and provoke controversies (Taillandier, Namias and Pousse, 2009). Some citizens and politicians seem to reject tall buildings altogether, regardless of the quality of their design, their position in the city or their contribution to the skyline. On the other hand, various enthusiasts and interest groups seem to embrace each new development without much criticism, as long the proposed building is higher than existing high buildings.

These controversies may very well explain why a substantial number of towns and cities have felt the need to regulate the planning and construction of this specific building type. Because all building activities are regulated in the Netherlands, policy makers and civil servants need a solid framework that helps them to approve or disapprove a specific high building proposal. The policy document that emerged in the Dutch context is called *Hoogbouwbeleid* (High Building Policy) or *Hoogbouwvisie* (High Building Vision). The high buildings policies bear resemblance to a number of policy documents recently produced in the United Kingdom and Germany: the Guidance on Tall Buildings by English Heritage and the UK Commission for Architecture and the Built Environment (CABE and English Heritage, 2007), London's Interim Strategic Planning Guidance on Tall Buildings, Strategic Views and the Skyline in London (Mayor of London, 2001), Birmingham's Planning Policy Framework for Tall Buildings (Birmingham City Council, 2003), the *Hochhausentwicklungsplan* Frankfurt am Main (*Stadtplanungsamt* Frankfurt am

Main, 2008) and the *Hochhausentwicklung in Düsseldorf Rahmenplan (Landeshauptstadt Düsseldorf, Stadtplanungsamt, 2004)*. In this chapter these policy documents are addressed as ‘high buildings policies’.

Height regulation is a key component of such policies. Height may be measured in many different ways: architectural height, floor-to-ceiling height, floor-to-floor height, highest occupied floor height, main roof height, observation deck height, observation floor height, roof height and tip height (Emporis, 2009).

Because the architectural height is internationally considered to be the official height for primary ranking purposes (Emporis, 2009) this article considers only the architectural height. The architectural height is defined as “the vertical elevation from the sidewalk level outside of its lowest exposed floorplate, to its highest architectural or integral structural element. These include fixed sculptures, decorative and architectural spires, ornamental fences, parapets, balustrades, decorative beacons, masonry chimneys, and all other architecturally integral elements along with their pedestals” (Emporis, 2009).

12.3 HIGH BUILDING DEVELOPMENT IN ROTTERDAM

Over the years, Rotterdam has carefully cultivated an image as a ‘city of architecture’. Historic architecture is not Rotterdam’s strong point. Few buildings were left standing after the bombing and fire of May 1940, and most of those were modern buildings from the 1920s and 1930s. The city had to rebuild its centre from scratch. It seized this opportunity to experiment with architecture and urbanism, which is why the Rotterdam city centre now contains numerous monuments and icons from the modern and modernist period, sometimes referred to as ‘reconstruction architecture’.

Discussions about the appropriateness of high buildings did surface from time to time, but never reached a climax, as they did in cities with historic centres. High buildings are now generally accepted and most are concentrated in the city centre. While Rotterdam as a whole uses modern and modernist architecture to promote itself, high buildings are an essential ingredient in the profile of the city centre: the skyline, including the famous Erasmus bridge, has become a true icon of the city (Ulzen, 2007).

Rotterdam’s semi-official history portrays a hundred-year prelude from the late nineteenth century, with the completion of the *Witte Huis* (1898; 42 metres) to the so-called ‘first wave’ of high buildings in the mid-1980s. It suggests that at the beginning of the 21st century, the city was on the verge of this ‘second wave’ of high buildings, which would feature super high



Figure 1
Weenatoren, Rotterdam city centre (106 metres; 1990)

buildings. Some remarkable difficulties arise with this. To begin with, if one considers the early years of Rotterdam's 'century of high-rise' as a prelude to the current high building developments. Neither the height nor the location of the high buildings dating from this early period relate to the municipal policy on high-rises. Although the first 'high' buildings were relatively tall for their time, they fall far short of qualifying as 'high' by current standards.

The HBU building (1939; 40 metres) is now dwarfed by numerous neighbouring buildings that are almost twice its height. Even the GEB tower (1931; 61 metres) is too small to qualify under the current policy on high buildings, which applies only to buildings of 70 metres or more. Similar difficulties appear when the locations of these buildings are considered. In the four decades, between the construction of the GEB tower and the completion of *Hoboken* (1969; 114 metres), almost all high buildings were built to the west of the city centre or in the western part of the centre, among them the characteristic *Lijnbaanflats* (1956; 44 metres). It was only in the 1970s that the current high-rise area in the middle of the centre began to emerge.



Figure 2
The HBU building, nowadays dwarfed by the neighbouring high buildings from the 1990's

To get a better understanding of how the development of high buildings has evolved over the years it is necessary to look at some data. Data on high buildings can be presented as a simple list or as a scatter plot. This chapter uses the scatter plots because it is a simple but efficient way to display the relation between two types of quantitative data tagged to a number of specific objects. A simple graph of height (y axis) versus time (x axis) can be plotted using data on the architectural height and the year of completion of the high buildings. By including buildings under construction and proposed buildings, a timeline for high building development in a given city emerges. This method to visualise high building development through time and height was used for the first time in a lecture series organised by the sLIM Foundation, initiated and funded by the Dutch Counsel on Tall Buildings.

The beauty of Rotterdam's scatter plot lies in the clear patterns that emerge. In her book 'Form Follows Finance', Carol Willis explains that the end of a high building wave is typically marked by the construction of the highest building so far (Willis, 1995). If that insight is also applicable to Rotterdam, then the year in which the tallest building so far was completed could be used

as the breaking points between ‘high building waves’. Four such buildings stand out in Rotterdam: the GEB tower (1931; 61 metres), the Faculty of Medicine of the Erasmus University, also known as ‘Hoboken’ (1969; 112 metres), the *Delftse Poort* (1991; 93 and 151 metres) and the *Maastoren* (2009; 165 metres). If the high building history of Rotterdam is indeed characterised by waves, then, these buildings are indicative of four such waves, as represented in the scatter plot. The end of a wave is determined by the latest and highest building in a development cycle. The beginning of the next wave is determined by referring to the last high building built immediately prior to an economic downturn, such as the ones in 1981, 2001 and 2008, when the Netherlands experienced negative economic growth.

The current municipal policy states that a high building is at least 70 metres high. This makes 1969/1970 a true watershed. First *Hoboken*, the building of the Faculty of Medicine, was completed (1969; 114 metres), followed a year later by the Faculty of Economics (1970; 78 metres). In the same, year the *Euromast* (a panorama tower) was extended with the addition of the Space Tower (1970; 185 metres). High buildings then sprung up in various locations throughout the city, ranging in height from 50-100 metres. The barrier of 70 metres was broken. Al-

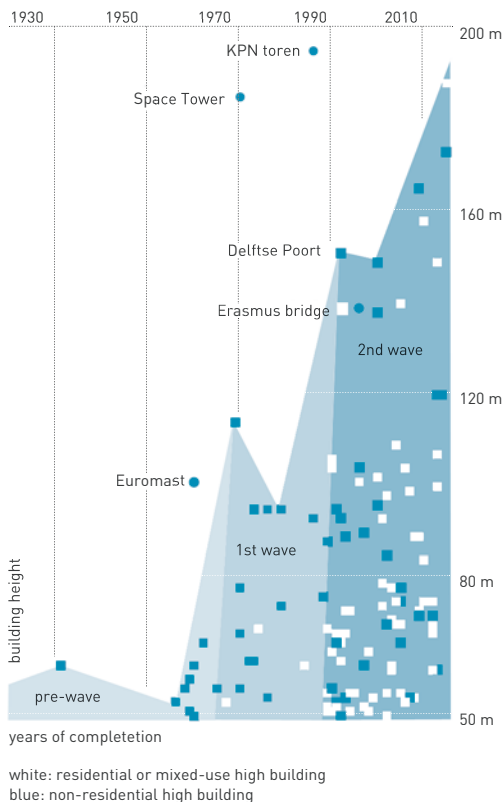


Figure 3
Scatter plot of the architectural height and the year of completion of Rotterdam’s high buildings, including optimised height categories and the so-called waves of high buildings

though there seemed to be no reason to turn back, the construction of high buildings came to an abrupt end in the late 1970s, when the city council imposed a moratorium on the construction of office buildings.

‘Rotterdam’ is not eager to acknowledge the fact that its first generation of ‘true’ high buildings appeared in the 1970s. When it speaks of a ‘first wave of high buildings’ they usually mean a later period, starting in the mid 1980s. Looking back at this ‘first generation’, it is easy to see why; there is little of which a ‘city of architecture’ can be proud. This first decade of ‘true’ high buildings did not produce many beautiful ones. Their architectural quality is mediocre at best, exemplified by the PTT Telecom building (1970; 51 metres and demolished in 2007), Europoint I, II and III (1973/76/79; 95 metres) or the Hofpoort (1976; 95 metres). Even their contribution to urban life is doubtful, since they are mono-functional building schemes without any public functions at street level. Regardless of the quality produced during this period, it was in fact the first period to produce a substantial number of buildings over 70 metres high. Furthermore, for the first time, a significant proportion of these high buildings appeared within the current high building zones.

All things come to an end, even a moratorium on new office blocks. After years of rapid economic growth, the economy slowed down in the early 1980s and went into recession. The port, which had been the pillar of the Rotterdam economy for the last century, was increasingly shedding jobs. It was no longer possible to overlook the high employment potential of the city centre. Politicians changed their views on barring office developments and the construction of office buildings picked up with the completion of the World Trade Center (1986; 93 metres), the *Maas* (1988; 76 metres) and the *Willemswerf* (1988; 88 metres). Since 1990, construction of high buildings in the central area has been in full swing: *Weenatoren* (1990; 106 metres), *Weenacenter* (1990; 104 metres), *Delftse Poort* (1991; 93 and 151 metres) and the Robeco Tower (1991; 95 metres). The number of high buildings built since the end of the ‘freeze’ was higher than normal, mainly due to postponed demand. This fact alone does not justify talk of a new era or ‘the first wave’. It was already pointed out in this section that the significance of the 1970s as an earlier wave is generally overlooked. Perhaps more importantly, there is little or no evidence of a significant change that took place during the mid 1980s.

When office building picked up in the mid 1980s, the city did not impose additional regulations on high building development. Neither did a shift in the location of new high buildings occur. Considering the architecture, evidence, albeit anecdotal, can be found to support the idea that this period is actually characterised by continuity instead of discontinuity. The last office building before the moratorium, the *Coolse Poort* (1979, 74 metres) was the work of Rob van Erk, who also designed the first building after the moratorium was lifted, the World Trade Center (1986, 93 metres). Both buildings have the mirrored glass facades that are so typical of the

late 1970s and the 1980s, and they stand just a few hundred metres apart. This is not what one would expect from a radical break.

Because the first high building wave is now estimated to have begun around 1970, the wave beginning in the late 1980s, early 1990s must be the second one. This second wave is not just defined by architectural height only. There are strong indications that a new trend emerged. The periods before and after 1989-1992 display many qualitative differences relating to urban planning policies, architectural design, internationalisation and the actual use of high buildings.

In 1993, the Rotterdam Municipal Council launched its first high buildings policy (*Hoogbouwbeleid*) in a structured attempt to steer the development of high buildings in the city (Dienst Stedenbouw + Volkshuisvesting, 2000). The architectural quality of high buildings from the era between 1969 and 1991 is mediocre at best, and for almost two decades, it was dominated by the use of mirrored glass facades. The *Delftse Poort* (1992; 93 and 151 metres) was the last design with such facades. The quality of architecture then improved and designs became more diverse.

In a parallel development, foreign architects became involved in the design of such buildings. In the preceding 100 years, no foreign architect had designed a high building in Rotterdam, with the exception of SOM with their three identical Europoint buildings (1975/1978; 95 metres). Since the mid-1990s, foreign architects have played a major role in high building design in Rotterdam. The buildings designed by foreign architects include Helmut Jahn's Fortis Bank (1996; 104 metres), Renzo Piano's Toren op Zuid (2000; 96 metres), WZMH's Millennium Tower (2000, 149 metres) and Norman Foster's World Port Centre (2001; 138 metres), Hans Kolhoff's *De Compagnie* (2005; 55 metres), Alvaro Siza's New Orleans (2010; 158 metres) and the list is growing.

Finally, there has been a marked difference in the use of high buildings. Before 1990, most high buildings were office or university buildings. The first partial shift to residential use took place with the construction of the *Weenatoren* (1990; 106 metres) and the *Weenacenter* (1990; 103 metres). The market was a little slow to adapt to this change, but the *Schielandtoren* (1996; 101 metres) and the *Hoge Heren* (2000; 102 metres) made the breakthrough. Many new high buildings and proposals are now for residential uses (Klerks, 2005).

12.4 ANALYSIS OF ROTTERDAM'S SUCCESSIVE HIGH BUILDINGS POLICIES

With these issues in mind, Rotterdam produced its first high buildings policy in 1993 as an integral part of the strategic plan for the city centre. Formulating such a policy document is a clear

characteristic of the second wave, and so it deserves a closer look. The 1993 policy covers both urban design and urban planning. The *Hoogbouwvisie* (High Building Vision) allowed high buildings only along the 'urban axis' formed by *Coolsingel*, *Schiedamsedijk* and the Erasmus bridge, along the *Weena* and along the river *Nieuwe Maas* (*Wilhelminapier*, *Kop van Zuid*). John Worthington (DEGW) advised the city to treat its reconstruction architecture along the boulevards with care. He proposed a setback principle and the city acted accordingly (Maandag, 2001).

Concentrating all the new high buildings along this one axis seriously limited the number of locations the city could provide. Within a decade, Rotterdam ran out of suitable plots. In a further development, the city faced proposals for buildings much higher than had been previously

Figure 4
Map of the 'official' Rotterdam high building zones



allowed. The policy provided no answers on how to deal with the shortages of building plots and the proposals for super high buildings; it was time for an update.

Almost ten years later, it was again John Worthington who gave the city advice on how to act. Worthington's firm DEGW (named after the partners Duffy, Eley, Giffone, and Worthington) proposed keeping the architectural heights along the river *Nieuwe Maas* relatively low and developing two concentrations of super high buildings at the beginning and the end of the urban axis. The river would then form a 'valley'. One focal point already existed: the Rotterdam Central public transport hub. The other had to be developed at 'Parkstad'. The 'valley' concept did not make it into the new policy and as a consequence, the *Wilhelminapier* remained a prime location for high and very high buildings. In the end, the policy document contained both quantitative and qualitative criteria; the high building zones in the centre were somewhat expanded and the city defined three different types of high building zones, each with its own height regulations:

- High building zones without height restrictions (*Weena* and *Coolsingel*);
- High building zones for buildings between 70 and 150 metres high;
- Transition zones adjacent to the other two high building zones.

According to the municipality these zones shouldn't be read as locations, but as areas in which locations can be found. The precise sites for high buildings remain to be determined within the framework of the municipal zoning plan. Among the qualitative criteria used in that process are public space, wind hindrance, living environment, accessibility, parking, flexibility, mixed-use, sustainability, construction and place (Dienst Stedenbouw + Volkshuisvesting, 2000).

Around the turn of the century, proposals emerged that surpassed the height of everything that was built before. The most controversial development concerned a super high residential building, the *Parkhaventoren* (392 metres; never built), next to the *Euromast* panorama tower (van der Hoeven, 2002). The proposal was an important impetus to update the city's high buildings policy. The original policy did not provide answers regarding how to judge proposals of this scale. Just after its revision was published in 2001, the economy stagnated. The demand for office space declined. The wave of super high buildings cooled off. The *Parkhaventoren* was never built and developments at *Parkstad* did not take off. In the end, the city approved the construction of just one 'super high building': the *Coolsingeltoren* (187 metres, never built), but even in this case, the developers were not able to find enough occupants to start construction. A new proposal for the site that was 156 metres high was stalled as a result of the 2008 credit crisis (Algemeen Dagblad, 2008). So far, the *Maastoren* (2009; 165 metres), which is located at the *Kop van Zuid*, is the only building that surpasses the *Delftse Poort* (1991, 151 metres). It may very well remain the highest building for some time to come.

Currently, there are no higher buildings or under construction. The *Maastoren* may close off just another wave in the Rotterdam tradition and possibly introduce a third wave. No matter how, the development of the Rotterdam skyline is at least in its second wave. Its first wave did not start in 1986 like the city claims, but already in 1969/1970. The second wave started in 1989/1992, still three to six years off from the city's 'official' first wave.

Using different waves and height categories may lead also to different conclusions on the extent of the envelopes of the clusters of high buildings, but first the visual impact of the high building cluster must be reviewed.

12.5 GIS-C-BASED VISIBILITY ANALYSIS

The visual impact of a singular high building was successfully reviewed (Lörzing et al., 2007) in the case of the proposed 'Belle van Zuylen' tower (262 metres, never built) near the Dutch city of Utrecht. See also chapter thirteen: Visions of Belle van Zuylen, for some background. The challenge faced in the case of Rotterdam is more complex. In question is the collective visual impact of 130 buildings between 50 and 165 metres high. In order to analyse and represent the visibility of the high buildings in Rotterdam, a comprehensive GISc-based viewshed method was applied (Rød and Van der Meer, 2009; Nijhuis, 2009; Germino et al., 2001; Nicolai, 1971). The accuracy of this analysis depends on the digital landscape model (DLM), the basis of computational visibility analysis (Fisher, 1991 and 1993; Riggs and Dean, 2007). According to Riggs and Dean (2007), the average level of accuracy which can be achieved is up to 85%. These findings suggest that it is better to express the analysis results in terms of probability (Fisher, 1995 and 1996).

However, to achieve the highest degree of reliability, an accurate barrier model or digital landscape model was constructed consisting of a digital elevation model (DEM) in combination with topographic data. The basis is a high-resolution elevation model, the *Actueel Hoogtebestand Nederland* (AHN-1, 1997-2003), which is precise to about 15 centimetres per square metre. The DEM's density, distribution and planimetric accuracy is such that topographic objects with a size of two by two metres can be identified clearly and with a maximum deviation of 50 centimetres (AHN, 2010). The model has been supplemented with recent topographic data: the digital topographic map at a scale of 1:10,000 (TOP10NL, 2009). All legend items were selected that are higher than eye-level (including ascending elements, buildings and trees and/or shrubbery) based on the definitions of the Topographical Service of the Land Registry (*Topografische Dienst Kadaster*). The location, architectural height and year of completion of the high-rise buildings were derived from the Emporis database (Emporis, 2010) and added to the digital topographic map. The resulting digital landscape model was corrected using recent aerial photographs, field surveys and Street View imagery (Google Earth, 2010).

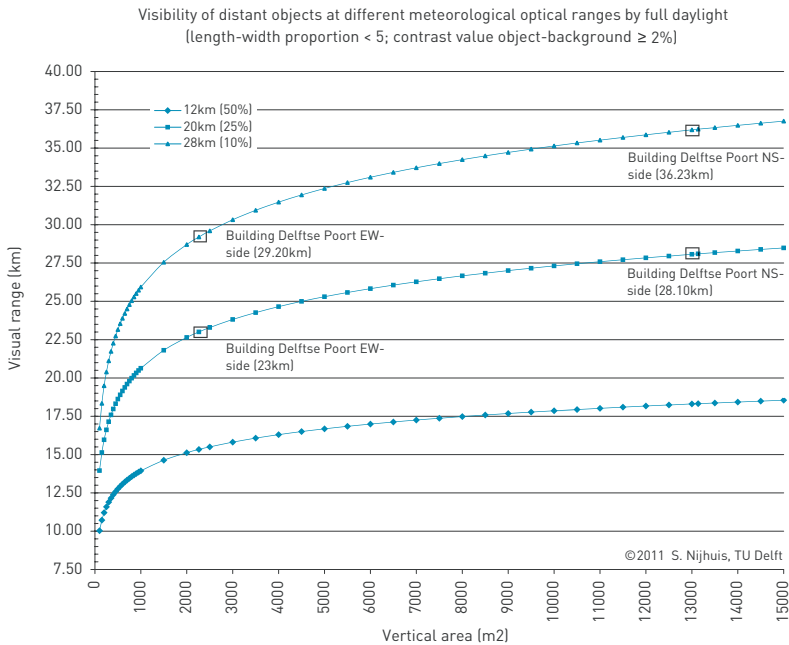


Figure 5
Visual range of high buildings as a function of the relationship between vertical area, shape and contrast value under different meteorological conditions by full daylight (source: Nijhuis, 2012)

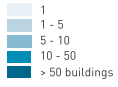
A number of parameters influence the result of the GISc-based viewshed analysis. Especially when it comes to high buildings the vertical size (area of the façade) and weather conditions play a crucial role in prediction of probable visibility (Nicolai, 1971). To put it more precisely, the visual range of objects in the landscape depends on: the apparent contrast between the object and its background, the angular size of the object, its shape and vertical area, the contrast threshold at the level of luminance (type of day), the conditions and technique of observing and; the eyelevel and related curvature of the earth (Duntley, 1948; Middleton, 1952). An important factor for determining the maximum visual range of distant objects is the meteorological optical range at different weather conditions. Observations from the Royal Netherlands Meteorological Institute (*KNMI*) show that the meteorological optical range by full daylight varies from nearly zero up to several tens of kilometres (KNMI, 2010). However, the average ranges of 12 kilometre (50% of the time), 20 kilometre (25%) and 28 kilometre (10%) are typical for Dutch circumstances (Nijhuis, 2012; Nicolai, 1971). For the analysis the maximum visual range of the high-rise buildings was calculated under different meteorological conditions by full daylight and involved vertical area (length-width proportion < 5), vertical shape (rectangular) and contrast value (object-background $\geq 2\%$). See figure 5. The vertical area was calculated by using fifty percent of the perimeter of the footprint multiplied by the architectural height.

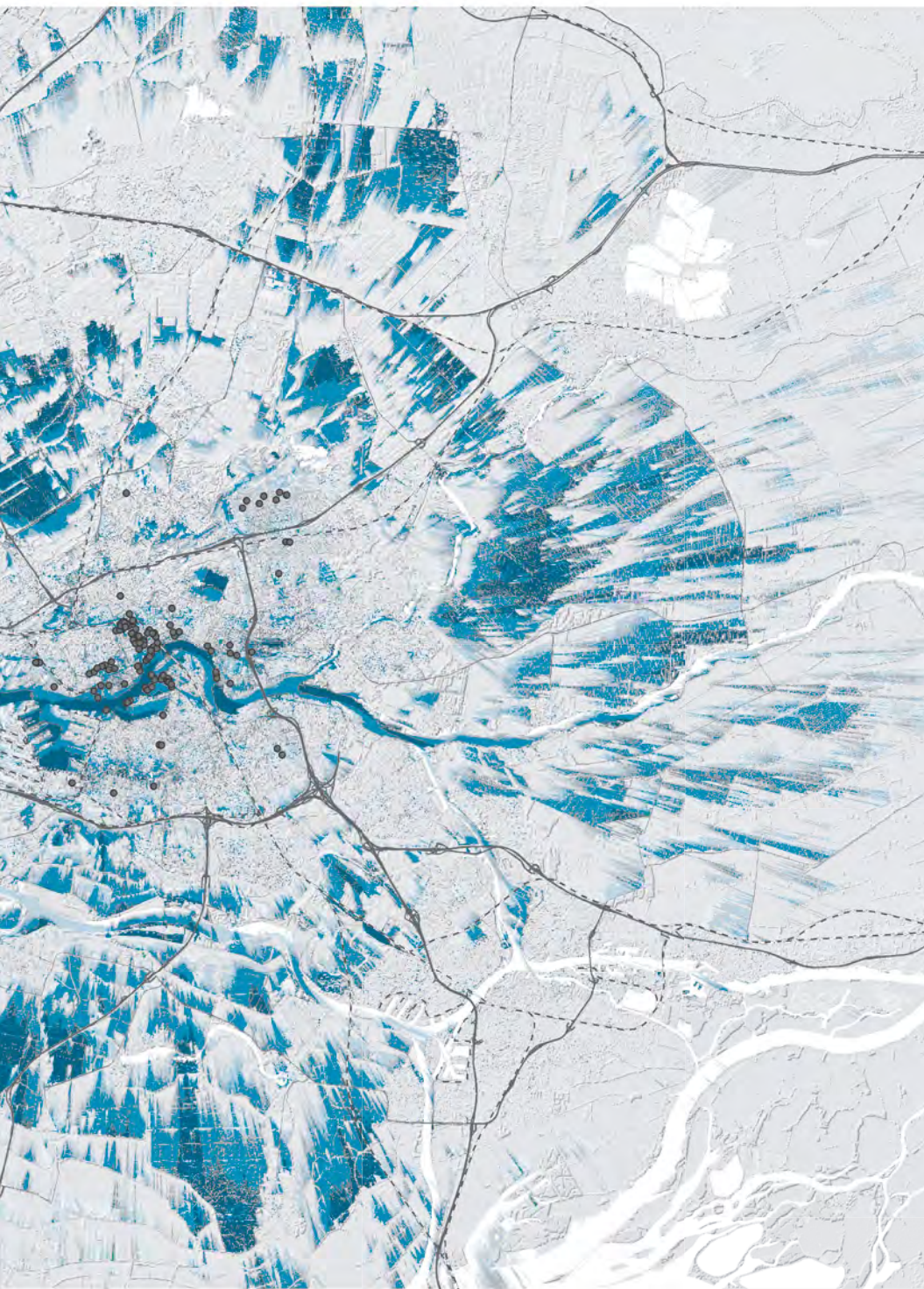
Figure 6

Visibility of high buildings in Rotterdam. Visual coverage (where) and the cluster effect (how many)

Visibility buildings > 50 meters

Full daylight: meteorological optical range 20km (25% of the time)
in relation to vertical size and area of the building





The cumulative viewsheds from the analysis show the probable visibility at a meteorological optical range of 20 kilometres and takes into account the curvature of the earth. The analysis results were tested for reliability through field visits and photos.

The GISc-based visibility analysis results show two important aspects of visual information with regards to high buildings: *visual coverage* and *cumulative visibility* (Nijhuis, 2009). The output is meant to be descriptive rather than normative. Visual coverage is about *where* you can see high buildings from in the open landscape (tinted: see e.g. figure 6) and the cumulative visibility is about *how many* high buildings you can see. Or, to put it like this: it represents the intensity, or amount of high buildings in the skyline of the city (gradual tint; from light to dark means increasing amount of buildings: see figure 6).

The visibility analysis of Rotterdam's high buildings shows that their combined visual coverage reaches various places out of town at distances of 5 up to and as far as 20 kilometres away. Within the city large bodies of open water (river, harbours, lakes) offer similar opportunities to see many high buildings simultaneously. In most of the town however the skyline cannot be seen.

This observation questions the relevance of using a winding boulevard (in combination with a setback principle) as an organising design concept for the urban setting of high buildings in Rotterdam. The collective visual impact of a high building cluster cannot be seen in the city itself. Outside the city, at a distance of 5 to 20 kilometres, the relative position between the individual buildings can't be assessed by the human eye. Whether the high buildings are neatly lined-up or randomly positioned is impossible to tell, unless they are all the same size and shape (which they are obviously not). As a result a skyline appears mostly as a two-dimensional phenomenon.

12.6 VISIBILITY OF ROTTERDAM'S HIGH BUILDING CLUSTER

To develop a better understanding of the visual appearance of the city's skyline it is helpful if the geographical coverage of the corresponding cluster is known. To determine this a simple outline can be drawn that links the outer buildings that are supposedly part of the cluster. If a new building is erected within the outline it will not change the width of the city's skyline, regardless the angle from which it is viewed. Any building erected outside the outline does extend the skyline, as seen from a specific angle. Three distinctive height categories were identified in Rotterdam: below 80 metres, between 80 and 120 metres, and above 120 metres. This means that three of such outlines can be drawn. In the case of most buildings it is clear whether they belong to such a cluster or not due to their proximity to the others buildings. The current Rotterdam high building policy assumes that high buildings in the Central District, the Centre, the



Figure 7
The skyline of Rotterdam seen from the Kralingse Plas

Nieuwe Werk and the *Kop van Zuid* are part of one continuous area. The question is if the high buildings west of this area belong to the area that makes up the visual skyline or not: *Park* and *Europoint*. From some angles these buildings west of the centre are visually part of the cluster and from other angles they are not. A simple technique can be applied to visualise this. The areas from which a building appears to be part of the cluster (or not) is determined by drawing two lines that connect the building in question with the two buildings that mark the borders of the cluster. If the angle between the two lines is larger than 90 degrees, then the area in which the building appears as part of the cluster dominates over the area in which it is visually separated from the cluster. The area from which the building doesn't appear to be a visual part of the cluster can be tinted for clarity reasons.

It appears that the buildings in the park area should be considered to be part of the cluster: *Hoboken* (1969; 112 metres) and the *Euromast* (1970; 185 metres). The *Europoint* I, II and III buildings (1973/1976/1979; 95 metres) are clearly not part of it. Interestingly, if we disregard the buildings at the *Kop van Zuid* and the *Nieuwe Werk* (all completed in the 1990's), then both *Hoboken* and the *Euromast* would not be part of the high building cluster. Expanding the cluster in the southward direction did integrate buildings west of the cluster as well. Adjacent to the cluster of buildings over 80 metres, additional buildings with a height between 50 and 80 metres can be found. All these buildings were reviewed one by one to assess whether they are part of the cluster or not. A third outline is the result of this action. All three outlines are displayed in the overall map.

The official municipal zoning map for high buildings and the area that actually governs the visual appearance of the Rotterdam skyline differ markedly. It seems that considerations on the visual appearance of the skyline didn't make it into the Rotterdam policymaking. This is unfortunate as it would be interesting to see a clear and substantiated stance whether to extend or to densify the skyline, to learn about which viewpoints/directions would be dominant in such a decision and

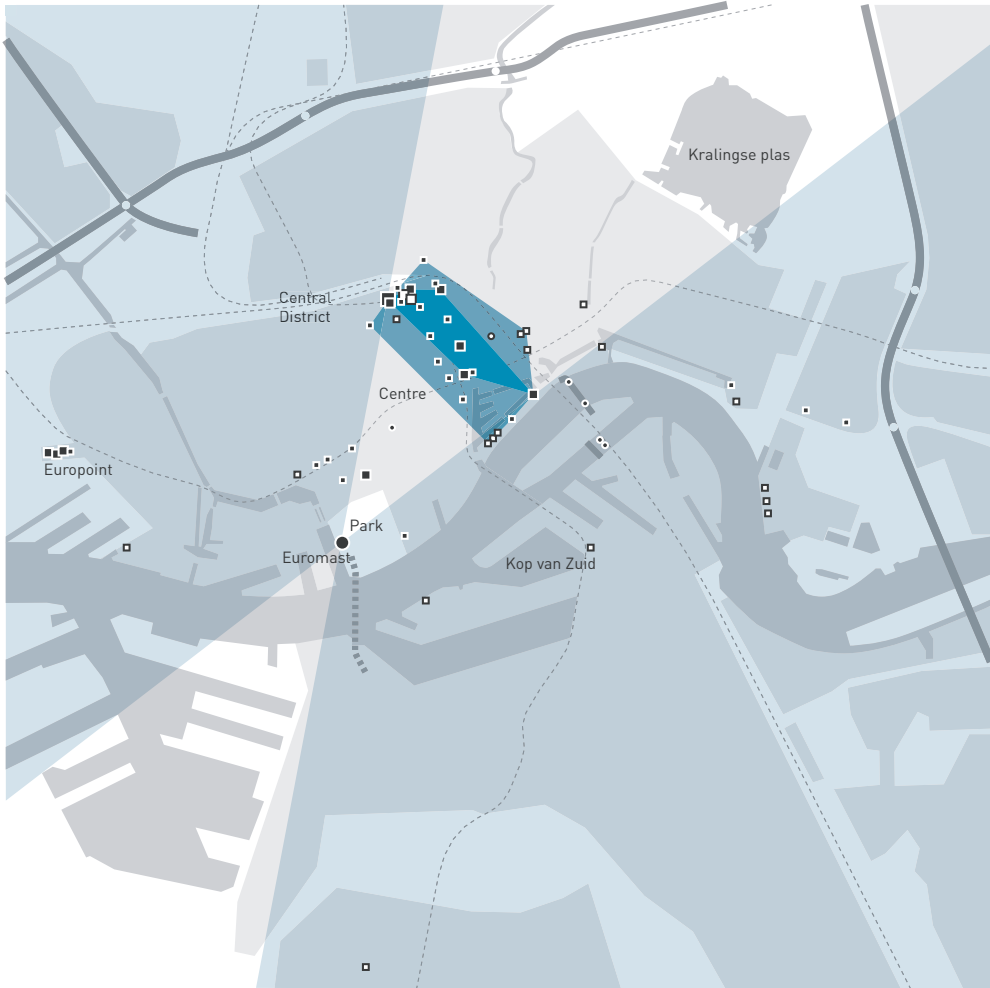


Figure 8
Areas from which the Euromast is visually part of the Rotterdam skyline and the areas from which it is not (tinted), based on the high buildings built before 1992

which would not. It would be equally interesting to learn why areas are excluded from the high building zoning that would actually not have an impact on the extent of the skyline.

After identifying the Rotterdam high building cluster, its visual range can be established. Because that cluster is 'layered' the role of the three height categories can be assessed in that process. The cluster's evolution through time can be visualised as well. This can be done by reviewing the development of the outline of the cluster's envelope(s) and by reviewing the evolving visual impact of the cluster on the city and its surroundings. Both directions are explored here.

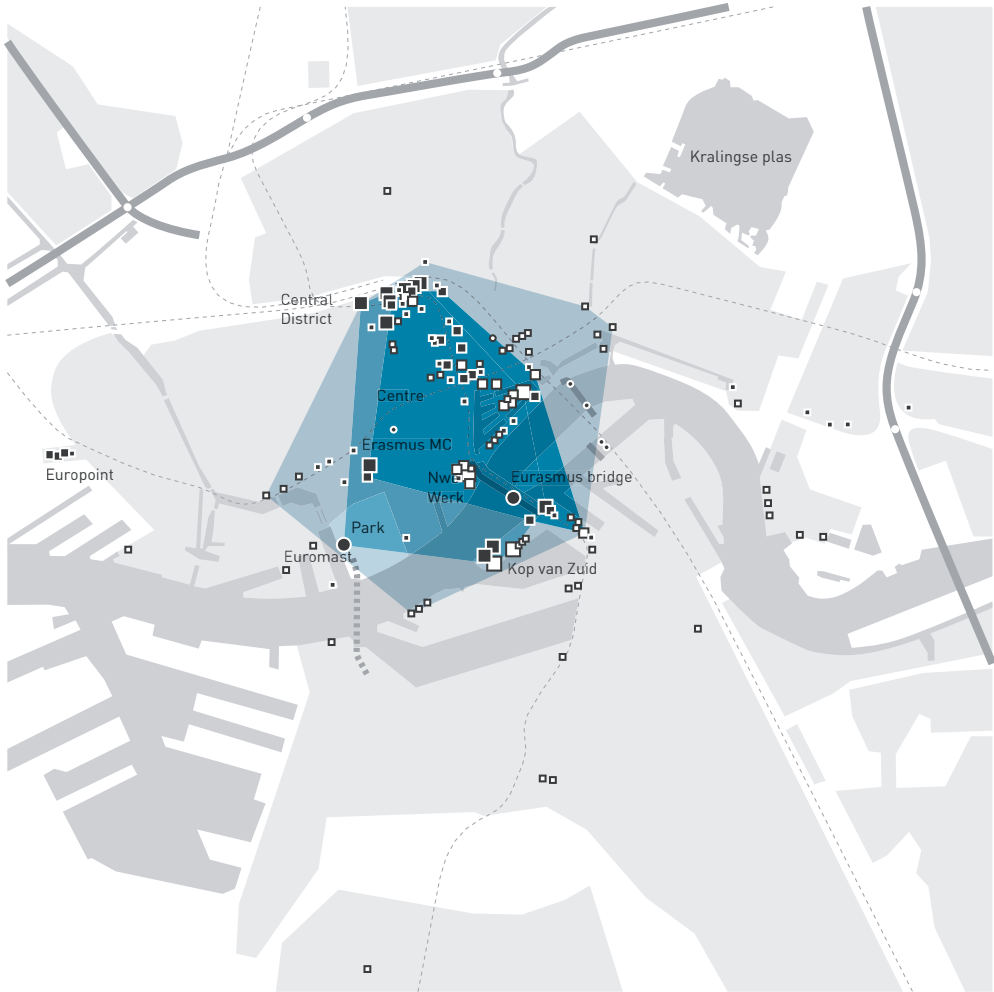


Figure 9
The 2015 multi-layered Rotterdam high building cluster

Outlining the high building cluster allows us to look back in time at its development. A first, though minimal, envelope of buildings over 80 metres can be drawn in 1989 after the third building in that height category is build in the city's centre, the *Willemswerf* (1988; 88 metres). A true envelope emerges however only in 1992 after the completion of most of the buildings in the Central District, as shown in figure 8. This confirms the analysis by means of the scatter plot that suggests a break over the years 1989/1992. By this time the cluster just contains one building over 120 metres, the *Delftse Poort* (1992; 151 metres). An outline for buildings in this height category is lacking for this reason.

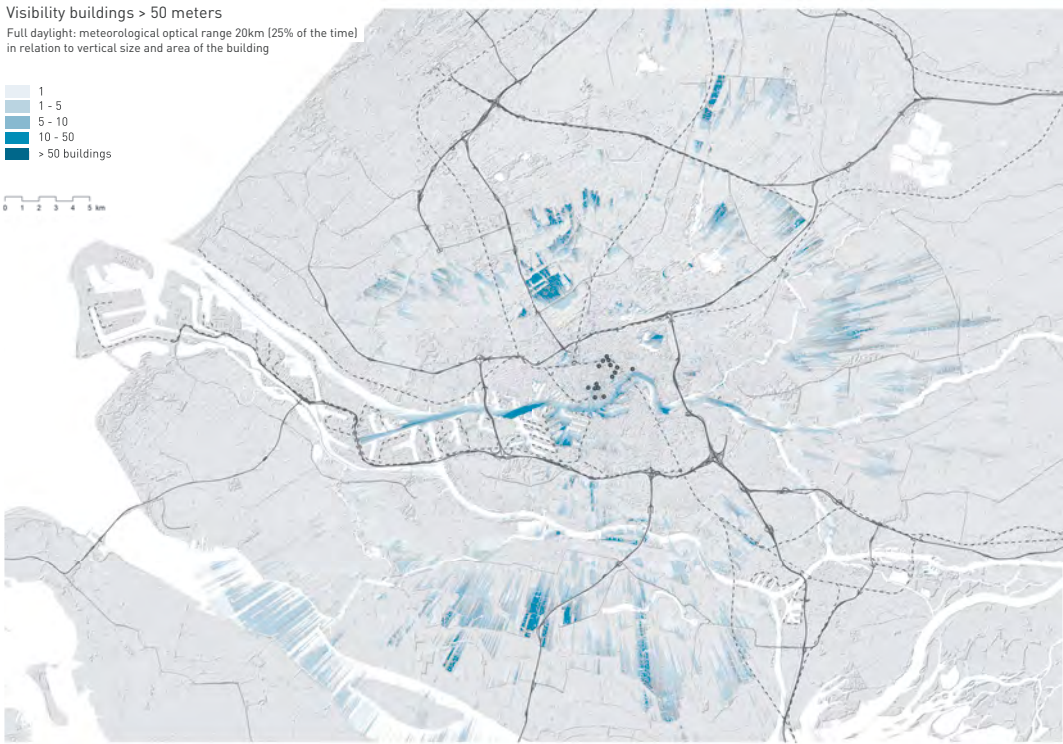


Figure 10
The Rotterdam cluster: visibility of the high buildings built in 1970 or earlier

A first (minimal) cluster of buildings with a height over 120 metres emerges with the construction of the World Port Centre (2001; 138 metres) that closes the triangle with the *Delftse Poort* (1992; 151 metres) with the Millennium Tower (2000, 149 metres). A true cluster emerges ten years later with the Red Apple (2009: 128 metres), the *Maastoren* (2009; 165 metres) and New Orleans (2010; 158 metres) and is reinforced by the buildings that are completed in the next few years, as shown in figure 9. The new Erasmus MC (2012; 120 metres) and the Euromast (1970; 185 metres) are part of that cluster. The accompanying maps show the visual coverage and cluster effect of the buildings that would nowadays be considered to be part of the cluster, at vital moments in the development of the Rotterdam skyline: 1970, 1992 and 2015. See figures 10, 11 and 12.

The analysis-results show that the visual coverage of high buildings outside the city was more or less established in 1970. The cumulative visibility (amount of visible high buildings) shows that the amount of singular buildings was high (visible coverage by one building). This implies that the 1970 skyline of the Rotterdam cluster was dominated by individual and small groups

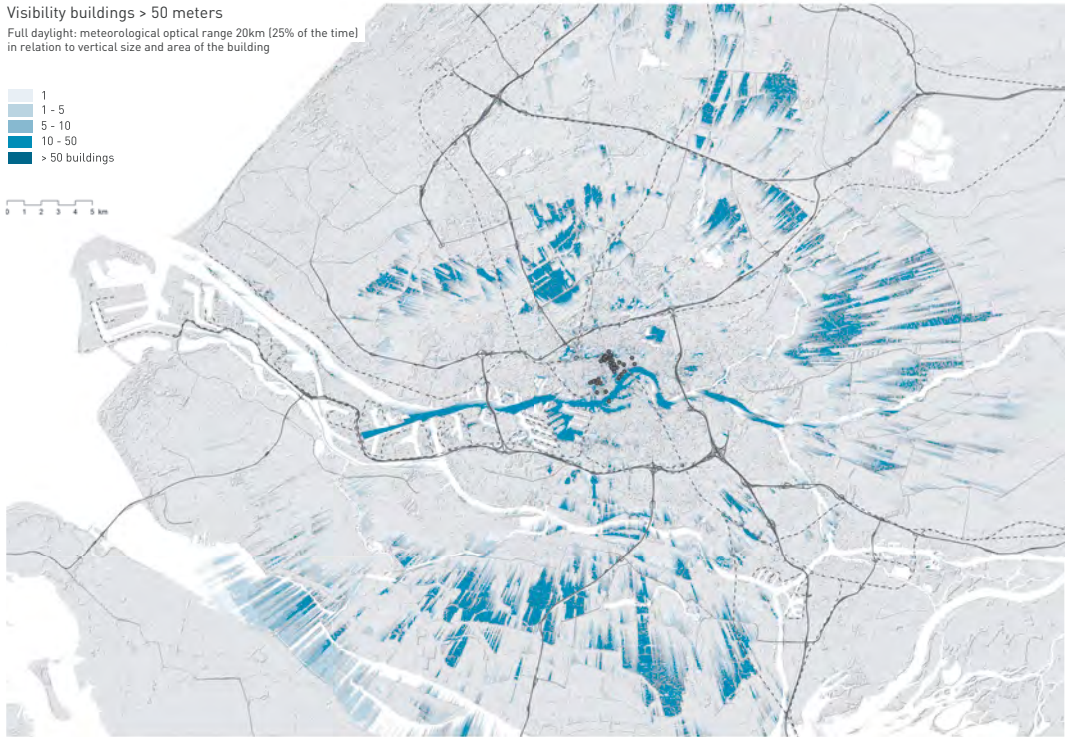


Figure 11
The Rotterdam cluster: visibility of the high buildings built in 1992 or earlier

of singular tall buildings. As stated before single landmarks are likely to be weak references by themselves. Their recognition requires sustained attention. However, in reality this usually does not happen. Of course sustained attention is also highly influenced by the angular size of the building involved; the further away the building is, the smaller its appearance and the smaller it gets, the more it tends to merge into the horizon. There is a slight increase of visual coverage over the years, especially north-west and south-west of the Rotterdam agglomeration up to 1992 and onwards.

However, the dominance of the cityscape dramatically increased over the years and is expressed by the increasing magnitude of cumulative visibility of high buildings. Especially in the last decades the cluster effect of high buildings in the skyline became the dominant development, in comparison with the development of increasing visual coverage. Starting north and south of Rotterdam in 1970 the visual accumulation of high buildings in the open landscape will develop into a city-embracing pattern in 2015. In summary, in 1970 most of the surrounding territory was visually covered by the city, but from 1970 onwards the skyline of Rotterdam

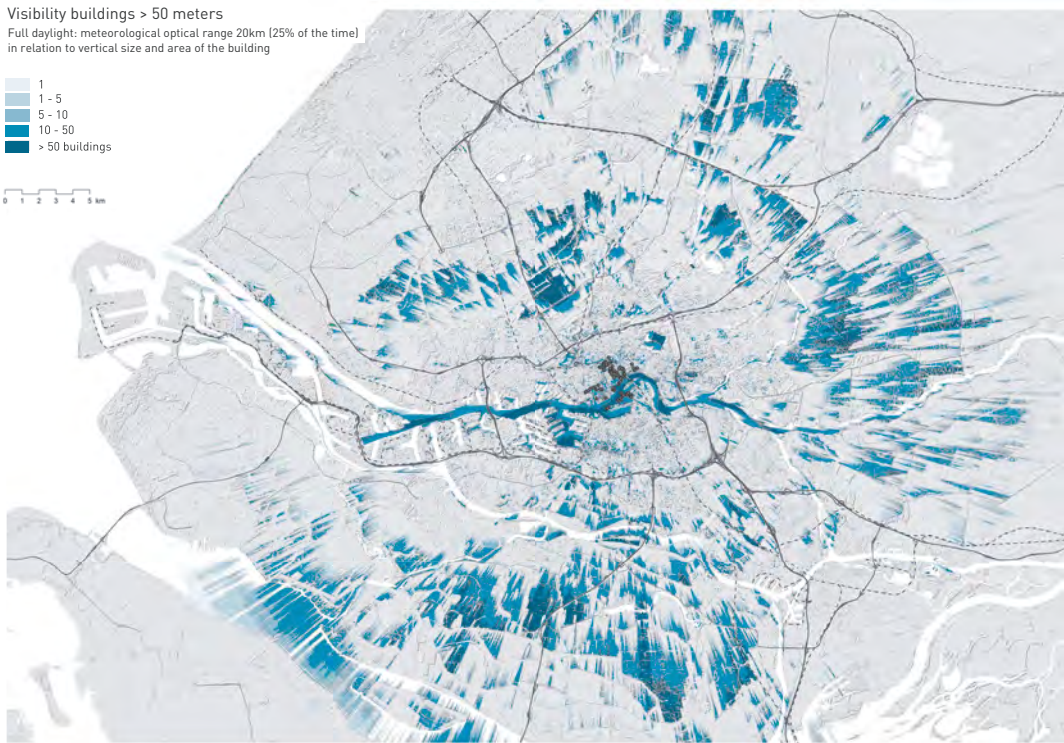


Figure 12
The Rotterdam cluster: visibility of the high buildings built in 2015 or earlier

became more important as a cityscape in the surrounding territory. These findings underscore that the fact that first wave of high buildings started in 1970, not just in 1986.

Another aspect to be analysed is the contribution of the different height categories ($< 80\text{m}$, $\geq 80 / < 120\text{m}$ and $\geq 120\text{m}$) to the visual coverage of the region. It is interesting that about approximately 80% of the visual coverage is established by the category 50-80 metres. Then the category ≥ 120 metres has more impact (about 3 %) on the visual coverage than the category 80-120 metres (17 %). With respect to the spatial cues: nearness, similarity and singularity, the height categories play a different role in the skyline of the city. Based on the visual coverage, the amount and distribution of buildings, we can conclude that the relative big amount of buildings within the category of 50-80 metres tends to merge together (nearness and similarity) and that the singular effect is formed by the higher buildings. However, evidence from future results has to underpin this conclusion.

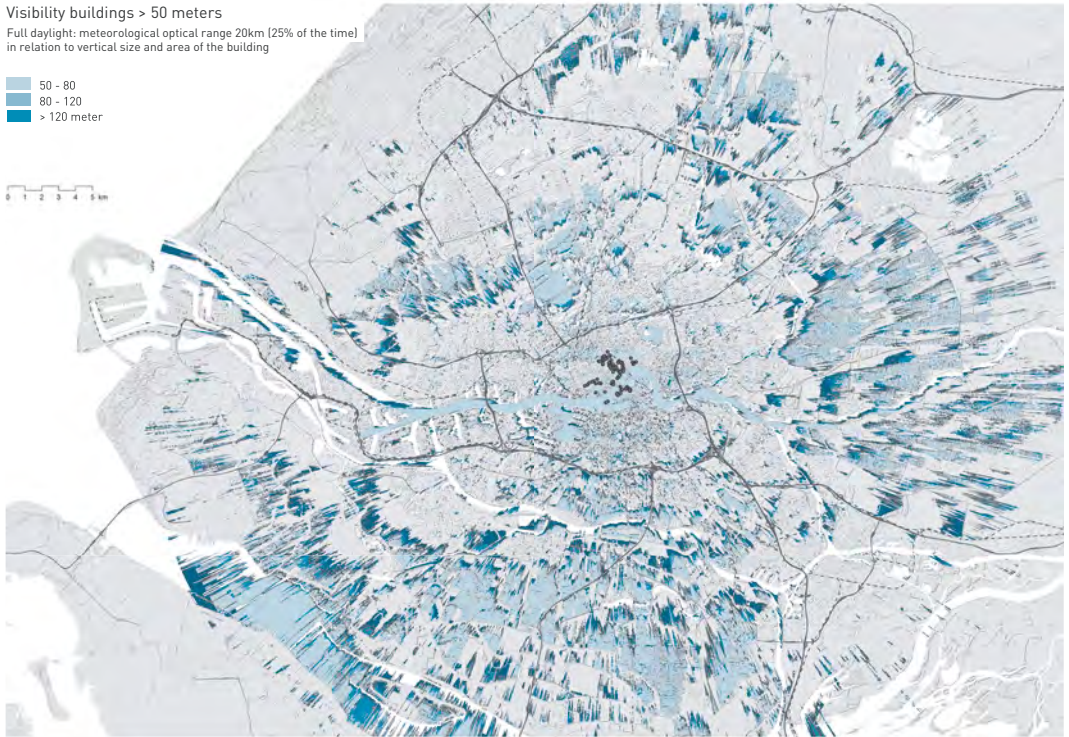


Figure 13
The Rotterdam cluster: visibility coverage of the three different height categories

12.7 CONCLUSIONS

The development of high buildings in Rotterdam is effectively analysed by considering the historical development in relation to the patterns that emerge from architectural height, year of completion, location in the city, and the functional use of the 130 buildings that measure 50 metres high or more. The height categories that were derived from this analysis are used to determine the visual impact that high buildings have on the city and its surrounding territory, and to determine the extend of the high building cluster that seem to drive the development of the city's skyline. The findings contradict the concepts of height categories and zoning used in the successive Rotterdam policy frameworks that were in place in the last two decades. Systematic research delivers new and robust height categories (less than 80 metres, 80-120 metres and above 120 metres) and a diamond shaped cluster that spans the core of the city's high building development already since early seventies. Both findings can be used as a solid scientific underpinning of a city's guidance on high building development.

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