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Visibility Analysis and Its Implications for Tall Building Policy

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Exploring the Skyline of Rotterdam and The Hague. Visibility Analysis and its Implications for Tall Building Policy

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This paper presents a systematic approach to analysing the visual impact of tall building evolution on cities and their surrounding landscape, using Rotterdam and The Hague as case studies. Critical tall building clusters that visually determine the skyline of both cities are identified and allow comparison of actual tall building development and the urban policies in place. The research demonstrates that a considerable distance exists between policy and reality. Both Rotterdam and The Hague struggle to deliver a consistent and integrated policy for tall-rise urban areas, while tall building developments seem to be ruled by an internal logic not fully recognized in policy-making. Using the visibility of the skyline to identify tall building clusters suggests that both cities could allow developments in a much wider area than originally envisioned in their guidance on tall buildings. Although each new tall building design faces public and political scrutiny, the fact is that the visibility pattern in both cities is already established. Each new development has a decreasing impact as long as it is confined to the established tall building cluster. As shown in the paper, GIS-based visibility analysis is a powerful tool for tall building planning and design, not only increasing understanding of actual developments and their effects in a precise and quantifiable manner, but also helping to evaluate and develop tall building policies.

For centuries, tall buildings have been important landmarks in the Dutch landscape for orientation, as anchor points for land surveying and for identity (figure 1). However, in recent decades the development of tall buildings has been controversial in the Netherlands, because of the visual encroachment on the surrounding landscape. Also concerns about the appropriateness of tall 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 policy-making. Therefore, several Dutch towns and cities have felt the need to regulate the planning and construction of this specific building type. On-line databases containing data on tall buildings (e.g. Emporis 2009–2017) show that at least three Dutch cities possess a sufficient number of tall buildings to justify such regulation: Rotterdam, The Hague and Amsterdam. Particularly here policy-makers and civil servants need a solid framework that helps them to evaluate new tall building proposals.

The policy document that emerged in this context is called *hoogbouwvisie* or *hoogbouwbeleid* in the Netherlands (Dienst Stedenbouw + Volkshuisvesting, 2000; Dienst Stedelijke Ontwikkeling, 2001). Dutch tall buildings policies bear a resemblance to a number of policy documents produced in the United

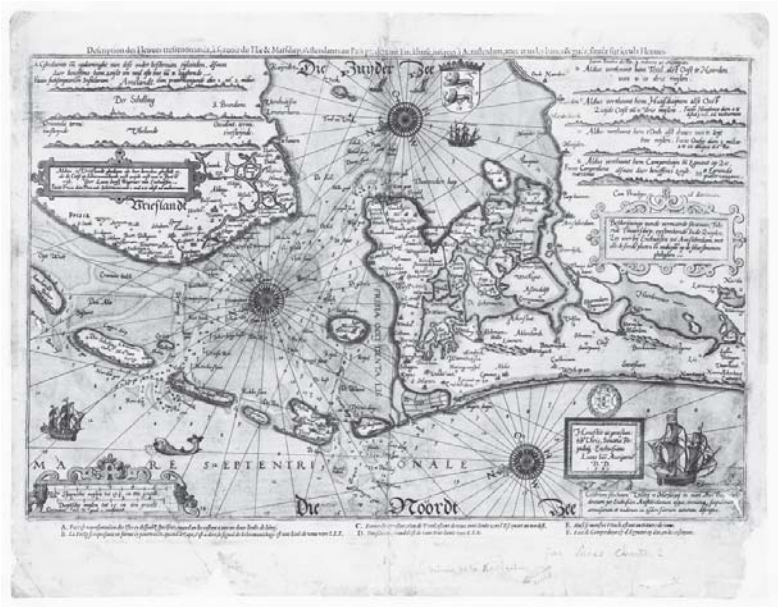

Figure 1. Tall buildings like church towers were in history used for navigation at sea. (*Source*: Sea navigation map of the Zuiderzee by Lucas Janszoon Waghenaer, 1590)

Kingdom and Germany over recent decades: the Guidance on Tall Buildings by English Heritage and the UK Commission for Architecture and the Built Environment (CABE & 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) or the *Hochhausrahmenplan* as it is called nowadays. In this paper such policy documents are referred to as 'tall buildings policies'.

Though all the cities mentioned above have a long tradition of urban management, building regulations and zoning plans, they still seem to feel the need for additional instruments to control the tall building development in the urban landscape of what can be described as an extremely complex spatial phenomenon: '… 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). Visual perception of the skyline has grown to become an important theme in the planning and assessment of tall buildings (figure 2).

Figure 2. The skyline of Rotterdam as seen from the Kralingse Plas is totally appreciated by its inhabitants.

Visual Impact of Tall Buildings

Research on the visual impact of tall buildings is important to guide and influence tall buildings development. For example, in the United Kingdom, debates over the appropriateness of projects in London and Liverpool are focused on view corridors (Appert and Montès, 2015), with UNESCO threatening to remove world heritage designations from historic complexes if the new developments damage their aesthetic impact. Although the visual impact on the local cityscape is widely acknowledged in the Netherlands, the visual impact on the regional landscape is hardly addressed in policy documents of municipalities and regional authorities. In isolated cases they might be developed, as in the investigation of the visibility of the proposed Belle van Zuylen tower, published in 2007 by the Netherlands Environmental Assessment Agency. At 262 metres the Belle van Zuylen tower would have become Holland's tallest residential building and the centrepiece of the Leidsche Rijn, a new city district west of Utrecht (Lörzing *et al*., 2007). But the Agency's research pointed out that the tower could be seen from most of the Green Heart, the semi-rural region enclosed by the cities Rotterdam, Amsterdam, The Hague and Utrecht. The report was the last blow for the proposed development – its construction was cancelled soon after the release of the report (Lörzing, 2011). As this report illustrates the visibility of tall buildings in their regional context is an important issue to address in tall building policy. Curiously the study did not show the joint visual impact of all the tall buildings in the region on the Green Heart, nor how much that impact would change as a result of the construction of the Belle van Zuylen. If the study had included all tall buildings, the report might not have caused such stir. In fact, a nearby television tower, the 367-metre Gerbrandytoren tower built 42 years earlier, already dominates the area visually. But how can we get a grip on the collective visibility of tall buildings in the landscape from the perspective of urban planning and design, and translate such notions into policy regulations?

Objectives of the Paper

This paper presents a systematic approach to analysing the joint visual impact of tall building evolution of cities and their surrounding landscape as a means for urban planning and policy development. Rotterdam and The Hague are used as case studies and previous research on the respective cities serves as input (Van der Hoeven and Nijhuis, 2011, 2012). The paper aims to elaborate on the view assessment of the skyline employing a comprehensive visibility analysis with GIS (Geographic Information Systems) that measures and simulates the visual appearance of the skyline from an observer's point of view. This increases not only the knowledge of the skyline's actual evolution and the spatial design principles involved, but also serves as a vehicle for policy evaluation. While using examples, critical tall building clusters are identified that visually determine the skyline of both cities and allows the comparison of the actual tall building development with the urban policies in place. In this way, the approach presented not only contributes to a proper understanding of the visual impact, but also to a reflection on the effect of tall building policies on the urban landscape as seen by its inhabitants.

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 meaning or connotation, depending on the context or the framework in which it is used. To avoid unnecessary confusion this paper consistently uses the term tall buildings. Buildings that are taller than 50 metres are regarded as tall buildings. Landscape is here defined as 'an area, as perceived by people, which character is the result of the action and interaction of natural and/or human factors' (Council of Europe, 2000). This implies that urban and rural areas are

both part of the landscape. So, when the word landscape is used it refers to the whole urban-rural continuum.

Next the tall building policy of Rotterdam and The Hague is introduced. Then, the skylines of both cities are analysed and discussed from the perspective of the tall building policies in place. The article ends with some concluding remarks on the relevance of visibility research in the development of skylines and the related tall building policies.

Tall Building Policy in Rotterdam and The Hague

Rotterdam is a prominent European tall building city and has a tall building policy in place. The city is part of the Emporis Top 20 of European tall building cities (Emporis, 2009–2017) – one of only four Western European cities to make it onto this list; the others are London, Paris and Frankfurt am Main. The city has 130 tall buildings with a height of 50 metres or more.

Rotterdam produced its first tall buildings policy in 1993 as an integral part of the strategic urban plan for the city centre (Dienst Stedenbouw + Volkshuisvesting, 1993). This policy covers both urban design and urban planning. This first tall buildings policy was quite restrictive. It allowed tall buildings only along the city's main 'urban axis' formed by Weena Boulevard, the Coolsingel, Schiedamsedijk, the Erasmus bridge, and the Wilhelminapier at the Kop van Zuid. An external advisor, John Worthington from DEGW, advised the city to treat its reconstruction architecture along those boulevards with care. He proposed a setback principle and the city acted accordingly (Maandag, 2001).

Concentrating all the new tall buildings along this one axis significantly limited the number of locations the city could provide. Within a decade, Rotterdam ran out of suitable plots. At the same time the city faced proposals for buildings much taller than had been foreseen. The original policy provided no answers on how to deal with the shortages of building plots and the proposals for super tall buildings; it was time for an update.

Almost 10 years later, it was again John Worthington who gave the city advice on how to act. Worthington's firm DEGW proposed keeping the architectural heights along the river Nieuwe Maas relatively low and developing two concentrations of super tall buildings at the beginning and the end of the city's main axis. The river would then form a 'valley'. One focal point already existed: the Rotterdam Central public transport hub near the Weena. The other had to be developed at 'Parkstad' near the Feyenoord football stadium. The 'valley' concept did not make it into the new policy. The Wilhelminapier along the Nieuwe Maas river remained a prime location for tall and very tall buildings. However, the option of developing tall buildings at Parkstad was included in the policy. In the end, the second policy of tall buildings (Dienst Stedenbouw + Volkshuisvesting, 2000) contained both quantitative and qualitative criteria. The tall building zones in the centre were somewhat expanded and the city defined three different types of tall buildings zone, each with its own height regulations (figure 3):

- Tall buildings zones without height restrictions (Weena and Coolsingel);
- Tall buildings zones suitable for buildings between 70 and 150 metres tall;
- Transition zones adjacent to the other two tall buildings zones.

A third iteration of Rotterdam's tall building policy was issued in 2011 (Dienst Stedenbouw + Volkshuisvesting, 2011). The number of zones was reduced from three to two: a so-called 'comfort zone' with tall buildings up to 150 metres and a 'super tall buildings zone' without height restrictions. Two super tall zones made it into the plan, one located near the Rotterdam Centraal public transport hub, and one along the river Nieuwe Maas at the Wilhelminapier at Kop van Zuid. This most recent document contains a number of qualitative criteria that are used to assess

Figure 3. Map of the 'official' Rotterdam tall building zones and the locations of tall buildings exceeding 50 metres.

the suitability of tall buildings according to how they relate to public space, cultural history, the design of their plinth, sunlight and wind, their visual appearance, architecture, construction and fire-safety devices, rooftop landscaping, parking, car-accessibility and sustainability.

An initial analysis of the consecutive Rotterdam tall buildings policies was made by the authors (Van der Hoeven and Nijhuis, 2012). In terms of zoning and height categories Rotterdam Urban Planning Department did not seem to have made an inventory of tall building developments as they developed over the decades. Sequencing time periods and carefully mapping tall buildings in a series of maps revealed that the city's policies were not very effective. A significant amount of development clearly took place outside the designated zones (figure 3). The discrepancy comes mainly from zoning not taking into account the history of current tall building developments.

Regarding the height categories, one could arrive at a similar observation. Visualizing the development of Rotterdam's skyline in a scatterplot based on building heights and years of construction revealed three significant height groups: buildings up to 80 metres, buildings with a height between 80 and 120 metres, and buildings with a height above 120 metres, this in contrast to the two height groups identified in the official policies (figure 4).

The second case the authors analysed was the city of The Hague. The Hague is not the official capital of The Netherlands, but is nevertheless home to the Dutch government, the parliament and all of the country's ministries. The construction of governmental offices is an important driving force behind the development of The Hague and its skyline. Most tall buildings are found in the city centre. The city has over sixty tall buildings over 50 metres. The tallest building has a height of 164 metres (figure 5).

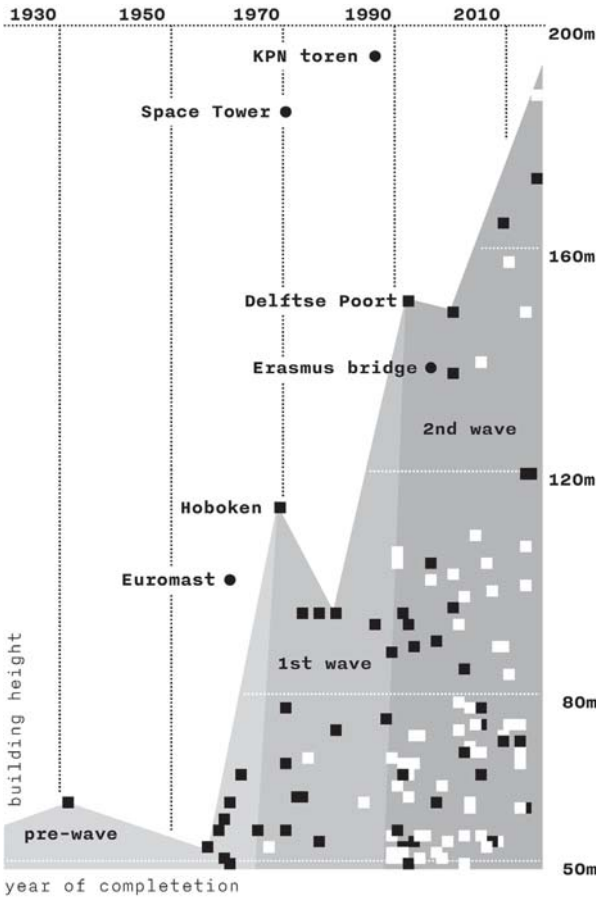

Figure 4. Scatter plot of the architectural height and the year of completion of Rotterdam's tall buildings, including optimized height categories and the so-called waves of tall buildings.

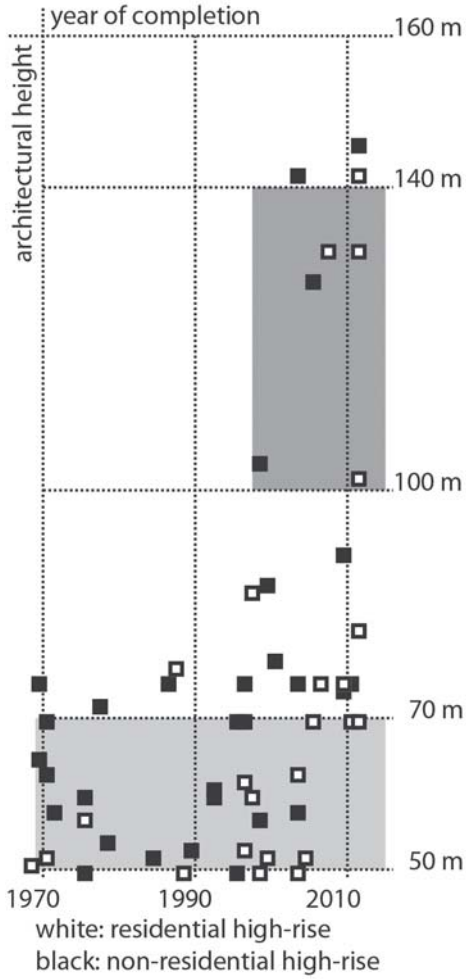

Figure 5. Scatter plot of the architectural height and the year of completion of The Hague's tall buildings, including the 'official' height categories.

The Hague started to develop its skyline from the early 1990s onwards. At present, it encompasses a remarkable portfolio of tall buildings designed by internationally renowned architects. The construction of tall buildings was initially halted by the outcome of a 1960s inner-city development that went sour. In the early 1960s, a local tycoon, Reinder Zwolsman, proposed a large real estate development based on a master plan designed by Luigi Nervi. It included a prominent office tower with a height of 140 metres just at the border of the historic district. The plan was legally contested and rejected (Van der Sluijs, 1989) by the country's highest court. The proposed tower was subsequently divided in two office slabs half the size (70 metres), which would house the Ministry of the Interior and the Ministry of Justice. The maximum height of 70 metres in this area was set in order to protect a culturally important view of the historic buildings of the Binnenhof, which houses the parliament (Freijser, 2000).

The formulation of The Hague's first tall buildings policy document (Dienst Stedelijke Ontwikkeling, 2001) coincided with the 1990s building boom. It was based on three main components: the architectural heights of buildings in the city; the development of tall buildings in the different city districts; and possible future developments. In this respect, the document introduced a distinct 'Hague Height' (*Haagse Hoogte*): a typical architectural height between 50 and 70 metres that was said to characterize the city's skyline up to the 1990s (figure 6). The policy document cites a number of reasons why buildings did not grow taller. One reason was that older policies prohibited buildings taller than 70 metres in the historic city centre. Another was the need to maintain an open corridor for transmissions from a telecommunication tower that was located just next to the centre. Both restrictions had been lifted in the 1990s and this fact was reflected in the tall buildings policy. It permitted buildings over 100 metres in specific areas. Nevertheless, the construction of buildings between 70 and 100 metres in height was explicitly prohibited. The city preferred to make a clear visual difference between buildings with a 'Hague Height' (50–70 metres) and a newer generation of markedly taller buildings (100–140 metres).

Looking at the actual heights of tall buildings in The Hague however, there seems to be no such thing as a typical 'Hague Height', at least not between 50 and 70 metres (figure 5) (Van der Hoeven and Nijhuis, 2012). In 2001, the year in which The Hague published its tall buildings policy, the city already had eight tall buildings between 70 and 100 metres tall; one building was under construction and three more buildings in this range were proposed. In the same year, The Hague had only one tall building over 100 metres. Three similar buildings were under construction and four others were proposed.

Figure 7 shows the map of the inner-city of The Hague, the location of existing and future tall buildings exceeding 50 metres and the 'official' tall building zoning. The zoning that was developed by The Hague had little bearing on reality. The city's policy failed to capture the developments in the Laakhaven area near the The Hague High-Speed train/public transport hub. A substantial number of buildings in the range of 50 to 70 metres had been built in this area just prior to publication of the policy. The zone for 100 to 140 metre buildings contains existing and planned tall buildings with a great variety of heights. However, it excluded the only building that was so far built in that the category of 100 to 140 metres: Castalia (1998, 104 metres), home of the Dutch Ministry of Health, Wellness and Sport. On top of that there was an issue with buildings of 70 to 100 metres and the buildings above 140 metres. According to the policy there should not be any of these buildings in the city. The municipal council's policy clearly states that buildings in this height range are undesirable because they alter the skyline of the historic centre. Also, it states that the maximum height in the city is fixed at 140 metres. Consequently, the tall buildings policy does not provide zoning for buildings of more than 70 metres.

Figure 6. Sketch, depicting 'The Hague height', originally included in the Tall buildings policy document of The Hague.

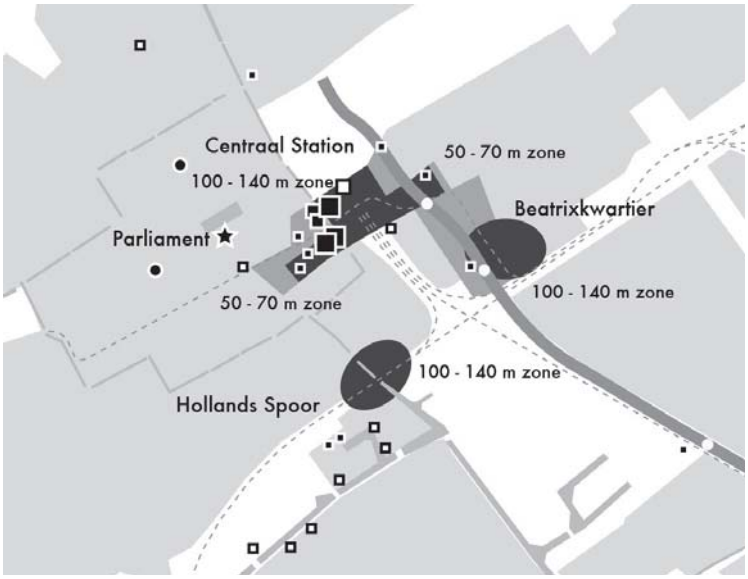

Figure 7. Map of the inner-city of The Hague with the 'official' tall building zoning and the locations of tall buildings exceeding 50 metres.

From this it follows that the height in the city could effectively be described by the same categories as in Rotterdam: up to 80 metres; 80 to 120 metres; 120 metres and above. The close proximity between Rotterdam and The Hague (just a little more than 20 kilometres) seems to create similar market conditions and technical constraints, resulting in comparable building heights.

Exploring the Skylines of Rotterdam and The Hague

Height regulation is a central component of the tall building policies of both cities. Height is important because it translates into the city's skyline, the visibility of the buildings and implies a certain visual impact on the local and regional landscape which, suffice to say, is relatively flat. Height may be measured in many different ways: architectural height; floor-to-ceiling height; floor-to-floor height; tallest occupied floor height; main roof height; observation deck height; observation floor height; roof height and tip height (Emporis, 2009–2017). Because the architectural height is internationally considered to be the official height for primary ranking purposes (*Ibid.*), this paper considers the architectural height, with the exception of spires, which play little or no role in the visibility of a skyline at greater distances. To assess the visibility of the skyline of both cities a GIS-based visibility analysis was performed.

GIS-based Visibility Analysis

For visual landscape research GIS has proved to be an excellent tool for modelling, analysis and visualization of complex spatial environments in urban planning and design (Nijhuis *et al.*, 2011). In order to analyse and represent the visibility of the tall buildings in Rotterdam and The Hague, a comprehensive GIS-based viewshed analysis was applied. This is a powerful means with which to get a grip on visibility issues in urban planning and landscape architecture (Nijhuis, 2015; Rød and Van der Meer, 2009; Germino *et al.*, 2001). Viewshed analysis is basically a three-dimensional visibility calculation and is useful to explore the skyline in both local and regional context.

The accuracy of computational visibility analysis depends on a three-dimensional digital landscape model (DLM), a virtual representation of reality (figure 8). According to Riggs and Dean (2007), the average level of

accuracy which can be achieved with viewshed analysis is up to 85 per cent. These findings suggest that it is better to express the analysis results in terms of probability (Fisher, 1995, 1996). Technically the DLM consists of a terrain layer – a digital elevation model (DEM) – supplemented with a volume layer of 2D and 3D referenced objects, like buildings, trees and other artefacts. The basis for the DLM is a tall-resolution elevation model, the *Actueel Hoogtebestand Nederland* (Digital Elevation Model Netherlands) (AHN-1, 1997–2003), obtained from airborne laser scanning with a precision of about 15 centimetres per square metre. The DEM's density, distribution and planimetric accuracy is such that topographic objects with a size of 2 by 2 metres can be identified clearly and with a maximum deviation of 50 centimetres (AHN, 2010). The model has been supplemented with digital topographic data of the respective time intervals at a scale of 1:10,000 (TOP10NL). All legend items selected were taller 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 tall buildings were derived from the Emporis database (Emporis, 2009–2017) and added to the digital topographic map. The resulting digital landscape model was corrected using aerial photographs, field visits and Street View imagery (Google Earth, 2010). In the case of Rotterdam multiple DLMs were constructed as time-slice snapshots in order to analyse the development of the skyline over time.

Figure 8. DLM of a section of Rotterdam.

A number of parameters influence the result of the viewshed analysis. Especially when it comes to tall buildings, vertical size (area of the façade) and atmospheric conditions play a crucial role in prediction of probable visibility. To put it more precisely, the visual range of tall buildings in the landscape depends on: field of vision of the observer; height of the building (angular size); curvature of the earth; shape and vertical area of the building (size of the façade); contrast between building and background (Nijhuis *et al*., 2011; Middleton, 1952; Duntley, 1948). However, the maximum visual range depends on atmospheric circumstances, and is referred to as the meteorological optical range. Observations from the Royal Netherlands Meteorological Institute (KNMI) show that the meteorological visual range in full daylight varies from nearly zero up to several tens of kilometres (KNMI, 2010). The vertical area, shape and contrast value of the buildings themselves are also important determining factors in their visibility. From this follows that the maximum visual range of tall buildings is a function of the relationship between vertical area, shape and contrast value under different meteorological conditions in full daylight and involved vertical rectangular area with a minimum contrast value (object-background $\geq$ 2%). Based on this relationship the maximum visual ranges

are calculated (figure 9) (Nijhuis, 2011).

The GIS-based viewshed analysis shows the probable visibility at a meteorological visual range of 20 kilometres in full daylight and the involved vertical rectangular area and minimum contrast value, and takes into account the curvature of the earth. The vertical area was calculated by using 50 per cent of the perimeter of the footprint multiplied by the architectural height. The analysis results were tested for reliability through field visits and photos. While taking into account meteorological conditions GIS enabled the unravelling of the maximum visual range, the visual coverage (where) and cumulative visibility (how many) of tall buildings. The analysis results show two important aspects of visual information with regards to tall buildings: visual coverage (where you can see tall buildings from in the open landscape) and cumulative visibility (how many tall buildings you can see). Or, put simply: it represents the intensity, or amount of tall buildings in the skyline of the city. The output is meant to be descriptive rather than normative.

Rotterdam

The visibility analysis of Rotterdam's tall buildings shows that their combined visual coverage reaches various places in the region at distances up to 40 kilometres away (based on the optical range of 20 kilometres in relation to the vertical size of the buildings). Within the city large bodies of open water (river, harbours, lakes) and their shores offer similar opportunities to see many tall buildings simultaneously (figure 10). In most of the city however, the skyline as such cannot be seen. This observation questions the relevance of using a winding boulevard in combination with a setback principle as an organizing design concept for the urban setting of tall buildings in Rotterdam. The collective visual impact of tall buildings cannot be seen in the city itself. Outside the city the relative position between the individual buildings cannot be assessed by the human eye from this bigger distance. Whether the tall buildings are neatly lined-up or randomly positioned is impossible to tell, unless they

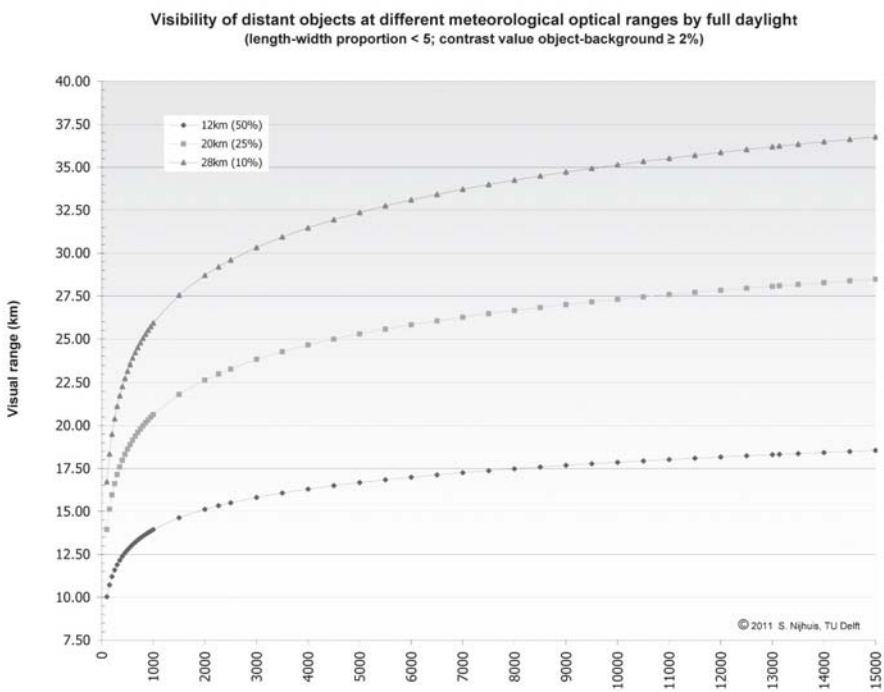

Figure 9. Visual range of tall buildings as a function of the relationship between vertical area, shape and contrast value under different meteorological conditions by full daylight.

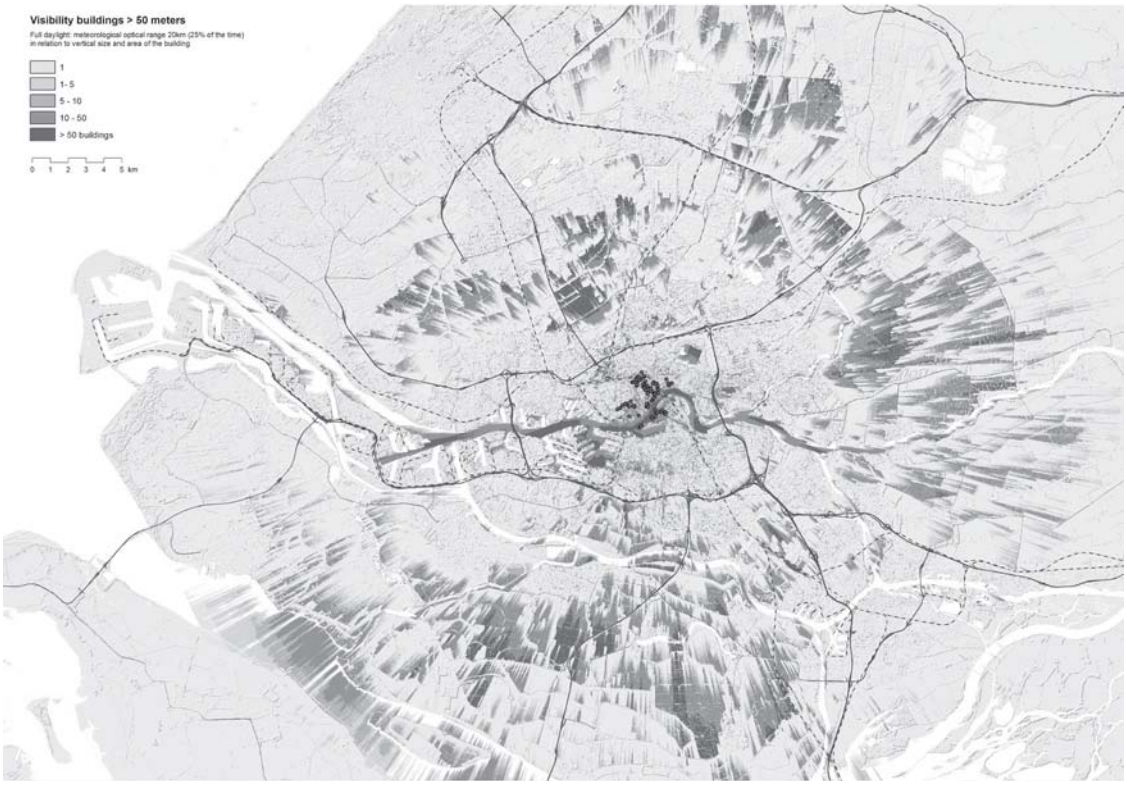

Figure 10. Visibility of tall buildings in Rotterdam in 2015. Visual coverage (where) and the cluster effect (how many).

are all the same size and shape (which they are obviously not). As a result, the skyline of Rotterdam appears mostly as a two-dimensional phenomenon (figure 2).

To develop a better understanding of the visual appearance of the city's skyline it is helpful to delineate the geographical coverage of the corresponding tall building clusters related to the earlier mentioned height categories: between 50 and 80 metres, between 80 and 120 metres, and above 120 metres (Van der Hoeven and Nijhuis, 2011). 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. In the case of most buildings it is clear whether or not they belong to the cluster due to their proximity to the other buildings. This means that three of such outlines can be drawn (figure 11). In the case of most buildings it is clear whether they belong to such a cluster or not due to their proximity to the other buildings. The current Rotterdam tall building policy assumes that tall buildings in the Central District, the Centre, the Nieuwe Werk and the Kop van Zuid are part of one continuous area (Dienst Stedenbouw + Volkshuisvesting, 2011).

The cluster's evolution through time can be visualized as well. Figure 12 shows that the visual coverage and effect of the tall buildings that are currently considered part of the cluster at vital moments in the development of the Rotterdam skyline with the appearance of significant tall buildings in 1970 such as Hoboken (1969; 112 metres) and the Euromast (1970;

Figure 11. Outlines of the multi-layered tall building cluster in Rotterdam (indicated in light to dark grey: 50–80, 80–120, >120 metres), as it appears visually in the territory that surrounds the city.

185 metres) and in 1992 with the Delftse Poort (1992; 151 metres). The results indicate that the visual coverage of tall buildings outside the city was more or less established in 1970. The cumulative visibility shows that single buildings in particular determined the visible coverage. This implies that the 1970 skyline of Rotterdam was dominated by individual and small groups of singular tall buildings. A slight increase in visual coverage over the years can be observed, especially north-west and south-west of the Rotterdam agglomeration, up to 1992 and onwards, with buildings such as the Maastoren (2009; 165 metres) and New Orleans (2010; 158 metres). However, the dominance of the cityscape dramatically increased over the years and is expressed by the increasing magnitude of cumulative visibility of tall buildings. In recent decades, the cluster effect of tall buildings in the skyline became the dominant factor. Starting north and south from Rotterdam in 1970 the visual accumulation of tall buildings in the open landscape developed into the city-embracing pattern as it is now.

The official municipal zoning map for tall 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 did not make it into the Rotterdam policy-making. However, as our analysis exemplifies, 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 which would not. It would be equally interesting to learn why areas are excluded from the tall building zoning that would actually not have an impact on the extent of the skyline.

The Hague

The visibility analysis of The Hague's tall buildings shows that the collective visual-impact of the tall building cluster can only be

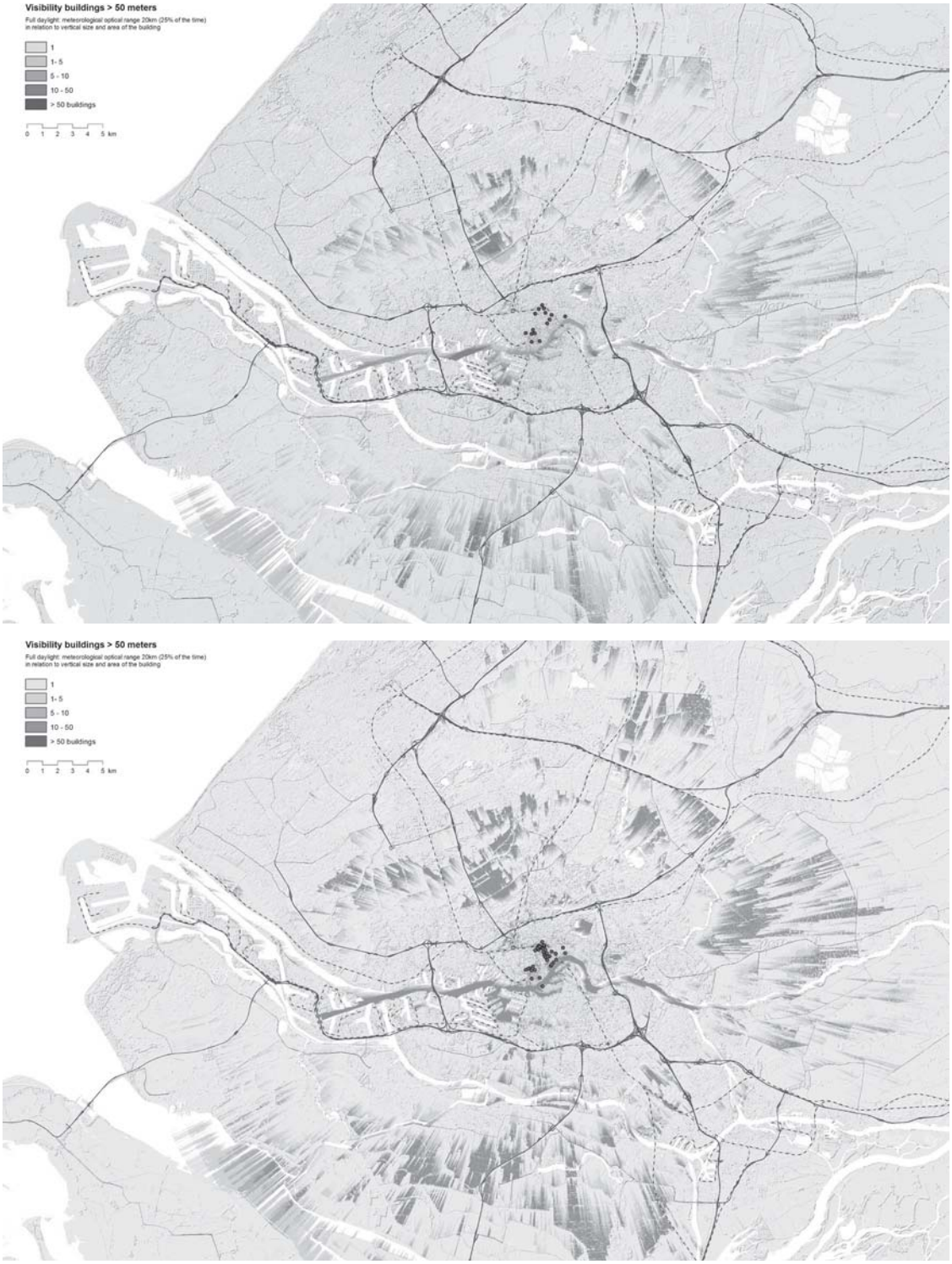

Figure 12. Visibility of the tall buildings in Rotterdam in 1970 (top) and 1992 (bottom).

seen at a few isolated spots in the city (figure 13). Outside the city the combined visual coverage of The Hague's tall buildings reaches to about 30 kilometres away with buildings such as Hoftoren (2003, 142 metres), New Babylon I (2011, 142 metres) and the Ministry buildings (2012, 146 metres). Especially from the North Sea, by boat one could observe the skyline of The Hague in total, as well as in some parts of the open farm land to the east of the city. Here also the tall building clusters are determined (figure 14); the same height categories are applicable (Van der Hoeven and Nijhuis, 2012). The outline that includes the buildings over 120 metres is substantial. The outline for the buildings between 80 and 120 metres is remarkably small. These buildings are all clustered in close proximity to The Hague Central transit hub. The outline of the buildings between 50 and 80 metres is somewhat larger than the over 120 metres outlines and defines a clear block surrounding The Hague Central station area. What emerges is a solid block of roughly 1.2 by 1.2 kilometres that seems to drive the skyline of The Hague with almost no difference between the lower and the taller height categories. That diagram is radically different from the one that was presented in The Hague's 2001 tall building policy document b ased on the architectural heights of buildings in the city, the development of tall buildings in the different city districts, and possible future developments (Dienst Stedelijke Ontwikkeling, 2001).

Figure 13. Visibility of tall buildings in The Hague in 2015. Visual coverage (where) and the cluster effect (how many).

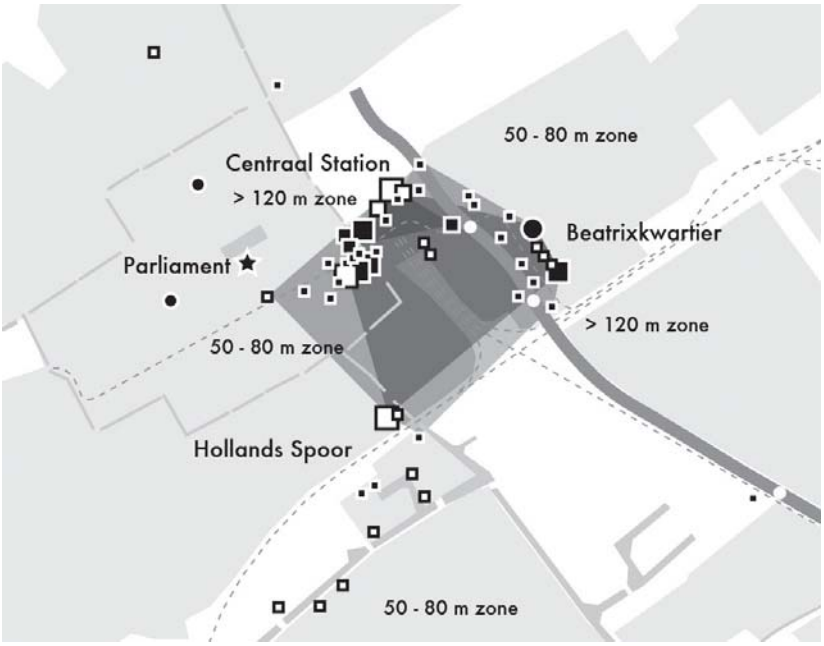

Figure 14. Outlines of the multi-layered tall building cluster in the centre of The Hague (indicated in light to dark grey: 50–80, 80–120, >120 metres), as it appears visually in the territory that surrounds the city.

Discussion and Conclusions

The approach as presented in this paper offered a way of understanding the actual tall building evolution in relation to the urban planning policies in place in two Dutch cities. The research presented demonstrates that there is a discrepancy between tall building regulations and actual developments in both cities. By systematically exploring the joint visual impact of tall buildings by means of GIS, critical tall building clusters could be identified that visually determine the skyline of both Rotterdam and The Hague. As a result, the findings contradict the concepts of height categories and zoning used in the tall building policies of the two cities. They seem to struggle to deliver a consistent and integrated policy for tall buildings, because tall building developments themselves appear to be ruled by a remarkable internal (visual) logic that is not reflected in the tall building policy. Using traditional urban elements like urban axes or riverfronts to structure tall buildings zones may no longer be appropriate.

As the result of an increased visibility, tall buildings are in most cases seen in places where citizens cannot see the streets or sites where they stand. At this point the visual interrelation of tall buildings within a cluster becomes a new aspect that should be considered in policies. From one angle a building may seem close to others, while from another it may appear to stand alone, quite far away from other tall buildings. Analysing which buildings visually appear more-often-than-not among other buildings allowed the authors to identify urban areas in which new buildings would not appear outside such a visual cluster (of buildings with a specific height). These areas proved to be considerably larger and more flexible than Rotterdam's and The Hague's official tall building zones. By using the visibility of the skyline as a means to identify tall building clusters suggests that the cities could allow developments in a much wider area than originally envisioned in both cities' guidance on tall buildings. Although each new tall building design faces public and political scrutiny, the fact is that the visibility pattern in both cities is already established. Each new development has a decreasing impact as long it is confined to the established tall building cluster.

From a Restrictive Tall Buildings Policy towards a Responsive Policy for High-Rise Urban Areas

Although the authors' analysis is critical, it should be noted that tall buildings in The Hague are iconic and designed by high-profile architects. The city has a long-standing policy on public space. Clear categories in the skyline can be recognized based on the height, year of completion and spatial location of tall buildings. The tall buildings are closely connected to both the main public transport hubs and the city centre. The Hague tall buildings are not randomly located but rather are carefully clustered. Clearly, the city council did manage efficiently its development projects in this area using principles and guidelines. Yet, by some remarkable twist, it failed to outline them in its first and only attempt to deliver a policy document on tall buildings.

The Hague's first tall buildings policy may have lacked maturity. The city seems to have refused to stand on the shoulders of its neighbour, Rotterdam. Rotterdam had already issued its third policy on tall buildings that clearly addresses qualitative aspects. Over the course of its history, the Rotterdam skyline has seen a number of increases in scale. These increases were moderate, never 'super'. It should be understood that a fragile equilibrium exists between local soft soil conditions, construction costs, the national building code (*Bouwbesluit*), the way the city determines land values, and the price that people and businesses are willing to pay for office space or housing. These conditions do not change overnight and they do not change simultaneously. As a result, the architectural heights and tall building cluster evolved slowly and gradually. In both cities, considering the historical development in relation to the patterns that emerge from architectural height, year of completion, and location three distinctive height categories can be recognized: from 50 to 80 metres, between 80 and 120 metres, and above (figures 4 and 5). These height categories can form a solid basis for the next generation of tall buildings policies in both Rotterdam and The Hague.

The policies developed so far seem to lack a strategic overview that binds the regulation of tall buildings into a comprehensive vision for urban areas designated for high-rises. Both policies (Rotterdam and The Hague) can be described as defensive or even reactive. A policy document that focuses on the question of where the tallest buildings in town should be built may not turn out to be the most effective. It is unlikely that the overall quality of the city centre will depend entirely on the impact of the location of a few buildings, either positive or negative. Instead of formulating a restrictive, reactive policy aimed at tall or super tall buildings, an active, responsive approach towards moderately tall buildings could offer better opportunities to diversify The Hague's and Rotterdam's centres. The importance of buildings between 50 to 80 metres should not be overlooked in that respect.

The area characterized by moderate building heights that the authors identified offers a larger number of possible locations than the tightly controlled zones for tall or super tall buildings. And yet, this wider area is still well connected to transit systems in both cities and to important public spaces in Rotterdam and in The Hague. Upgrading the spatial quality of these public spaces, improving their connection to the transit system and the existing tall buildings, supporting the leisure economy, and safeguarding the architectural quality of new tall buildings should all be part of such an integrated policy for tall-rise urban areas, firmly aimed at attracting new inhabitants, businesses and institutions to the city centre. Such a strategy relies on an active learning approach at all times to help potential investors and developers find suitable locations and guide them through the local decision-making processes. It is time to explore the full potential of the added value of tall buildings in the city centres of Rotterdam and The Hague.

Conclusion

The discrepancy between tall building policy and reality can be explained by the fact that in Rotterdam and The Hague tall building zoning is based on traditional urban design concepts such as building alignment, setback principle, visual axis and typical height without scientific underpinning of its visual effect on the skyline. As this research illustrates tall building policies should pay extra attention to the relation between the urban design concepts employed and the visual impact on the city itself and the surrounding territory. Particularly here the skyline dominates the landscape and is visible as a collection of tall buildings for commuters, visitors and residents. Especially in the flat Dutch landscape the cities' skyline can be seen from far away. And with the close proximity between Rotterdam and The Hague both cities can even be seen from the same area. Therefore, the authors would like to emphasize that this important characteristic of tall building development is so far neither analysed nor put into policy guidance.

In more general terms the paper exemplifies that GIS-based visibility analysis is a powerful tool for tall building planning and design. On the one hand, it helps increase the understanding of the actual evolution of the skyline and its effects in a precise and quantifiable manner at different scale levels. On the other hand, it can help to evaluate and sharpen tall building policy and regulations. Such an approach contributes to a proper understanding of the visual properties of the skyline in relation to planning principles and contributes to the scientific underpinning of a city's guidance on tall building development, thereby mitigating some of the emotional elements that often enter into the discussions. Understanding how the visual footprint of the city has evolved over time and testing how future development can be guided has to be an important step in a next iteration of tall building policies for cities across the world.

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