TeMA

This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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Naples

2014

Smart City

planning for energy, transportation
and sustainability of the urban system

TeMA

SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND

SUSTAINABILITY OF THE URBAN SYSTEM

Special Issue, June 2014

TeMA

Journal of
Land Use, Mobility and
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TeMA

This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

−   Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;

−   Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;

−   Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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VISUAL IMPACT IN THE URBAN ENVIRONMENT

THE CASE OF OUT-OF-SCALE BUILDINGS

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ABSTRACT

Recently, there has been an increasing need to apply methods for the estimation of the visual impact of buildings that are out-of-scale on its surrounding urban space, such as skyscrapers. In this paper, a method developed by the authors for the visual impact of buildings based on the viewshed analysis is applied to the out-of-scale buildings of the city of Turin. The method goes beyond the sole information if a cell is visible or not, which is typical of viewshed analyses, and also takes into account the various factors that cause the visual attenuation with the distance such as the visual acuity, the contrast between the target and the surrounding, the atmospheric visibility and the recognition process of the subject. The application of this methodology is done on two out-of scale buildings of the city of Turin – Italy (two skyscrapers, one of which is under construction, located in different areas of the city). From the visibility maps, in various conditions, it can be noted how the new buildings are or will recently be major landmarks not for the entire city but also for the surrounding municipalities.

KEYWORDS

urban environment; viewshed analysis; skyscrapers; visual perception;

1   INTRODUCTION

Usually visual impact refers to the modifications that a new development has on the viewing conditions of a landscape, however it is seldom an easy task to determine the effect of the view obstructions and the re-shaping of the skyline, both in urban (Moser et al., 2010; Guney et al.,2012) and rural areas.. For an urban visibility study, it is necessary to take into account, besides the topography, the building elevations and the urban atmospheric visibility. Visibility studies for rural and forest landscape are well established in the scientific literature in the last years, while there are not many visibility studies for the urban space, and most of them are based on a 2D representation (e.g. isovist) due to the difficulty to take into account building heights and other factors. Otherwise, it is possible to concentrate only on a small parts of a city, as some recent studies have done (Bartie et al., 2013). Among the factors that can modify the viewing conditions in a city there are certainly the out-of-scale buildings like skyscrapers, especially in urban environments characterized by uniform building heights like many European cities.

In the design of a skyscraper, the most important modifications on the urban landscape that should be studied are the variation of the skyline of the city, the visibility of the building from visual corridors of the main streets and the compatibility with the surrounding architecture, especially when such projects are developed in traditional Italian cities that are characterized by building height low and where buildings are comfortably seen by people on streets (Minucciani and Garnero, 2013). In such cases, there is the need to estimate the visual impact of a building on its surrounding, in order not only to redesign the city skyline from some representative viewpoints, but also to understand where this building can be seen from and how much of it can be seen. Urban landscape studies can answer these questions.

The city of Turin has been thinking about the construction of new out-of-scale buildings for a long time. First, in 1995 the new land-use planning instrument of the city allowed the construction of two tower buildings in an area near the historical city centre and in correspondence of a new main street that covered the railways. These towers had a maximum number of floors equal to 21 and a total height of 75 m maximum. Later on, through various modifications, the maximum height went beyond the value of 75 m up to 150 and finally in 2008 to 210 m for a second skyscraper. From the first idea of two towers, many new projects have been designed and by now two main skyscrapers are under construction (one in the original location of the first tower, the second one in a different location) and various projects for new skyscrapers are under development. This has also been generating a vast debate on the opportunity of building such new out-of-scale buildings in a city like Turin which is characterized by building height lower than 20 m (De Rossi and Durbiano, 2006). The present paper intends to give a quantitative and objective contribution about the estimation of the visual impact of such new out-of-scale buildings.

2   OBJECTIVES

In order to study the visibility of an out-of-scale building within a urban environment it is necessary to use GIS procedures that consider together both terrain and built environment representations and model the interaction between humans and the space.

In this work, a visibility study on the two new out-of-scale buildings of the city of Turin is conducted by means of a method, sufficiently simple but accurate, to generate visibility maps of symbolic buildings that applies not only the standard binary approach that is used in visibility analysis (an integer result to identify if the cell of a raster is visible or not), but also takes into account more realistic factors that depend on the human vision and on the outdoor environment like the visual acuity, the atmospheric extinction and a visual psychological threshold. The detailed discussion of this method can be found on Garnero and Fabrizio (in

press). Finally, it should be noted that the visibility analysis performed in this study were developed on the area of the entire city of Turin, which counts 130 km^2, and it is one of the largest cities in Italy.

3   MATERIALS AND METHODS

Visibility studies in urban space were conducted in the past by means of isovists (Benedikt, 1979). An isovist is the visual field that is wholly visible from a certain single point that is the feature of interest and it is mapped as the continuous area of a two dimension polygon. With the creation of isovist generating computer applications (Daltonand Dalton, 2001), there has been the possibility of moving the point of interest. The concept of isovist (Batty, 2001) has been later employed for the study of spatial properties of indoor spaces (Turner et al., 2001; Franz and Wiener, 2005; Wiener et al., 2007; Arabacioglu, 2010) rather than urban spaces.

A viewshed is a binary representation of the visibility of a location from a certain viewpoint and is usually computed by means of standard functions of GIS software tools from the DTM. The result is a Boolean variable that identifies if each cell is visible (value 1) or not (value 0) from a certain viewpoint.

When the results of various viewsheds from different viewpoints are added up using raster algebra of GIS tool, the result is called cumulative viewshed and is characterized by an integer result: in this way how many viewpoints are seen at cell can be identified.

Viewsheds and cumulative viewsheds can be easily calculated by means of standard GIS tools, however they suffer from the limitation due to the lack of the visual attenuation with distance, so that when the distance increases the results of a viewsheds analysis are merely theoretical. The method that will be applied is based on a raster representation of the built environment and on the use of viewshed analyses that is described into Garnero and Fabrizio (in press). This method calculates three different limit visibility distances based on the visual acuity (Eq. 1), on the atmospheric visibility and on the possibility of detection of an object.

The limit visibility distance due to visual acuity, indicated hereinafter as $d_{l,v}$, is equal to

$$d_{l,v} = \frac{D}{\tan\left(a\,\dfrac{\pi}{60\cdot 180}\right)} \cong D\,\frac{60\cdot 180}{a\,\pi} \tag{2}$$

where a is the visual acuity in minutes of arc and D the object size. Considering an object that has a size of 20 m (that may be, for example, one of the two dimensions of a building plan), the maximum distance at which it can be seen is 69 km with a visual acuity of 1.

Even though visual acuity sets a physical limit to the mutual view distance between two points in a GIS model, in practice in many cases the atmospheric visibility may limit the maximum visibility distance rather than the visual acuity. Values of visibility distance can be obtained from weather registration stations where usually the visibility is measured in km. Rather then specific weather registrations, a typical behaviour of this parameter can be found on the test reference years[1] (TRY) used for example for the energy performance calculations, and will be adopted later. The mean monthly values of the hourly values of visibility for the Torino location are reported in Figure 1, where it can be found that the lower values of visibility occurs in September and October, while the greater values occurs in August and January. Between the lower and the

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[1]   A Test Reference Year (TRY) is a file that contains the 8760 hourly values of the various weather quantities representative of the mean climatic conditions of a location, see for example the TRY computed by the ASHRAE within the International Weather for Energy Calculation programme. They were initially developed to be used in order to determine the heating and cooling energy needs of buildings.

greater visibility there is a difference of 7 km. Atmospheric visibility sets therefore a time variable limit visibility distance that is indicated hereinafter as dl,a.

Finally, not only the physical aspects of the vision (visual acuity, contrast, etc.) but also the psychophysical effect of perception should be considered, because visual acuity regards only the possibility that an object is seen from a certain distance but does not assure that the subject detects and recognizes the object. To take into account this perceptive side of the vision, visual thresholds were introduced in psychopysics: a visual threshold is the minimal stimulus that can be perceived, a sort of a boundary between detecting and not detecting (Shang and Bishop, 2000).
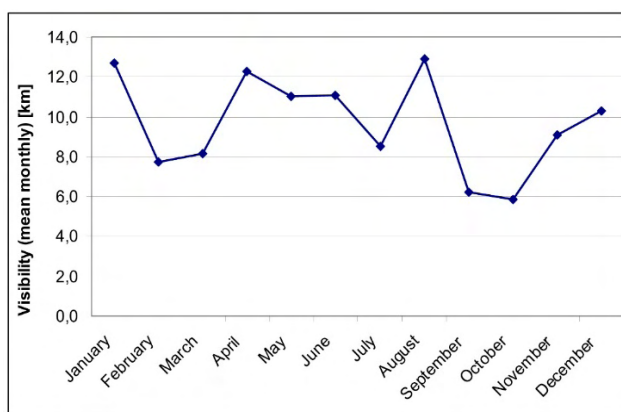
FiG. 1

Having defined the visual size (or magnitude) S as the portion of the field of view that is occupied by the object and measured in square minutes, the limit visibility distance for the psychological perception $d_{l,p}$ can be determined as

$$d_{l,p} = \frac{180 \cdot 60}{\pi} \sqrt{\frac{DH}{S}}$$

(2)

where D and H are the horizontal and vertical target dimensions. Shang and Bishop (2000) have plotted on graphs which have visual size (in square minutes) and visual contrast as axes, thresholds curves that express the trade-off between threshold visual size and the threshold visual contrast for the informed recognition, the uninformed recognition and the uniformed detection. These curves, and the related logistic regression equations also derived, can be used in landscape studies to determine the visual impact on object introduced on the landscape and were adopted in this work.

For example, considering the uninformed recognition of a target characterized by object sizes equal to 20 m and 70 m, for a visual contrast of 30% the threshold visual size is equal to 50 square minutes and the limit visibility distance for the psychological perception is 18,19 km. If the contrast falls to 13% the threshold visual size is 100 and the limit distance becomes 12,26 km, while at the lowest value of contrast (7 %) considered by Shang and Bishop (2000), the threshold visual size is 250 and the limit distance becomes 8 km.

4   IMPLEMENTATION ON CASE STUDIES

The visibility analysis was conducted on the study area of the city of Turin, one of the largest cities of the North-West of Italy, and on the two new out-of-scale buildings, two skyscrapers (one under construction

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and one at the end of its construction stage). The general specifications concerning the study area are reported in the following paragraph, and then the analyses are conducted for each case study building.

4.1 TERRAIN MODEL

The terrain height is the new DTM of the Piedmont Region which has a cell size of 5 m x 5m. Data for the present work have been provided by Regione Piemonte survey aimed to the production of a digital orthoimage at 1:5000 scale and a digital terrain model at Level 4 in accordance with Intesa specifications (CISIS, 2011) as reported in Table 1 (Godone and Garnero, 2013).

Type	DEM or DSM
Accuracy: bare ground *PH(a)*	0.30
Height accuracy: with tree cover > 70% *PH(b)* (DEM)	0.60
Height accuracy: buildings (DSM) *PH(c)*	0.40
Height tolerance: bare ground *TH(a)*	0.60
Height tolerance: with tree cover > 70% *TH(b)* (DEM)	1.20
Height tolerance: buildings (DSM) *TH(c)*	0.80
Planimetric accuracy: *PEN*	0.30
Planimetric tolerance: *TEN*	0.60
Cellsize:	5

Table 1. Specifications of the DTM level 4 - CISIS document "*Ortoimmagini e modelli altimetrici a grande scala - Linee Guida* (Large scale orthoimagery and elevation models – Guidelines)" shows Level values (meters)

A LIDAR survey was carried out by the employment of ALS 50 II sensor (Leica Geosystems) with MPIA (Multiple Pulse In Air) technology with the following features:

- Maximum Pulse Rate: 150000 Hz (150.000 points/second);
- Maximum scanning frequency: 90 Hz (90 lines/second);
- 4 echoes (1°, 2°, 3°and last);
- Flying height: 200 - 6000 m above ground;
- Field Of View (FOV): 10° – 75 °;
- Side overlap: 200 - 600 m;
- Intensity measured each echo.

In addition to the ordinary survey, in a portion of Regione Piemonte, a more detailed one has been required. It was characterized by the following parameters:

- FOV (Field Of View): 58°;
- LPR (Laser Pulse Rate): 66.400 Hz;
- Scan Rate: 21.4 Hz;
- Average Point Density:0.22 pts/m²;
- Average Point Spacing: 2.12 m;

The study area is the city of Turin and counts 9 sections at a scale of 1: 10.000 which were jointed on a single DTM resampled at a cell size of 0.5x0.5 m. This resampling obviously does not add any improvement in the quality of information, but was done in order to operate the following calculations. The representation of this DTM is reported in Figure 2 where it can be noted that from west to east there is a slow slope up to the Po river, then there are the hills on the south-east part of the DTM.

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4.2   BUILDINGS MODEL

As regards the buildings, the information was taken from Technical City Map of Turin, a cartography on a scale of 1:1000, updated each 6 months with topographic measures. It was obtained as a shape file and with the eaves height of each building. In particular, the 3D model of the city is subdivided into primary (main) and secondary (small) buildings, and every height is derived from aereophotogrammetry techniques.
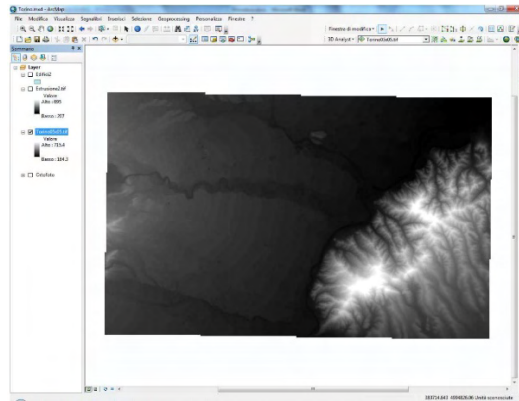
Fig. 2

There are:

—   64,679 main buildings, of which 3,515 have the eaves height equal to zero. In order to retrieve, at least approximately, the heights for these buildings, for which the information on the number of floors above ground was in any case available, the eaves height was estimated summing up the building height (as number of floors by 3 meters) to the ground level.

—   65,334 smaller buildings, of which 28,870 have the eaves height equal to zero; these are mostly low buildings and were deleted.

4.3   GIS PROCESSING

The ArcGIS 10.1 tool was used in all the processing. In order to obtain an information consistent between the two bases of data available, the vectorial data were transported into raster data using the GIS "Polygon to raster" command, which produces a raster with a cell size of 0.5 m, that reports all eaves height of the buildings, and *nodata* where there are not buildings.
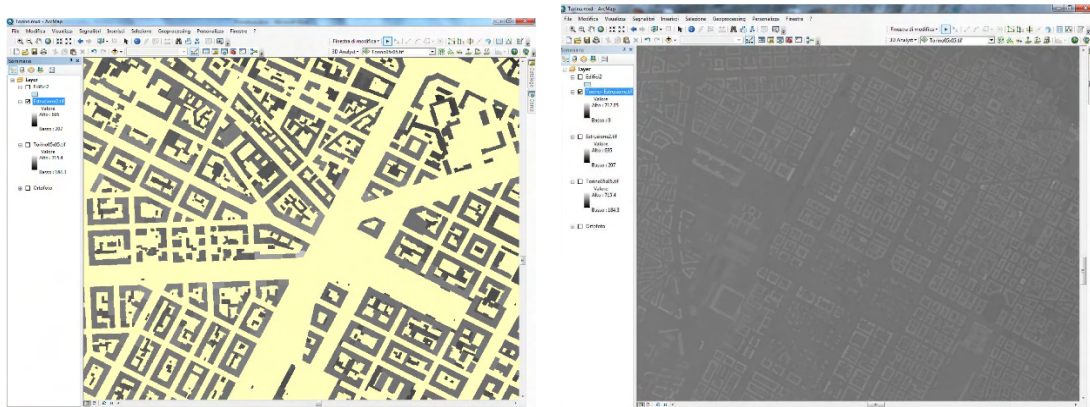
Fig. 3 and Fig. 4

At this point, the two models (DTM and buildings) were merged using the raster calculator and generating a new raster that has the value of the regional DTM if the building raster is null, otherwise it has the value of the building eaves height. In practice, this is a sum of the buildings DTM and of the terrain DTM that produces a DTM where buildings are "extruded" with a cell size of 0.5 m.

A 3D view of the city model (where the height of the buildings was not emphasized) is reported in figure 5. All buildings are coloured in brown while the skyscrapers under consideration in the following paragraphs are coloured in green.
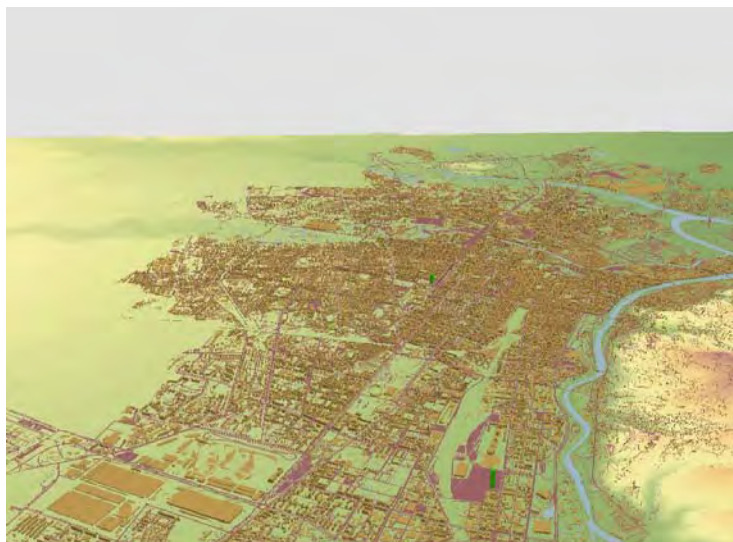
Fig. 5

4.4 THE LIMIT VISIBILITY DISTANCE FOR THE ATMOSPHERIC EXTINCTION

In order to consider two different conditions characterized by a different behaviour, the two months with the greater and the lowest visibility values were selected. These are August, with a mean monthly visibility of 12.9 km, and October with a value of 5.8 km (Figure 1). In Figures 6 and 7 the frequency distributions of the hourly values of visibility for those two months are reported. It is easily seen that the frequency distribution of the month with the lower visibility is centred on low values with a maximum at 2 km, while for the month with the highest visibility there is not only one maximum and the distribution presents values spread from 4 km to 35 km.

Fig. 6 and Fig. 7

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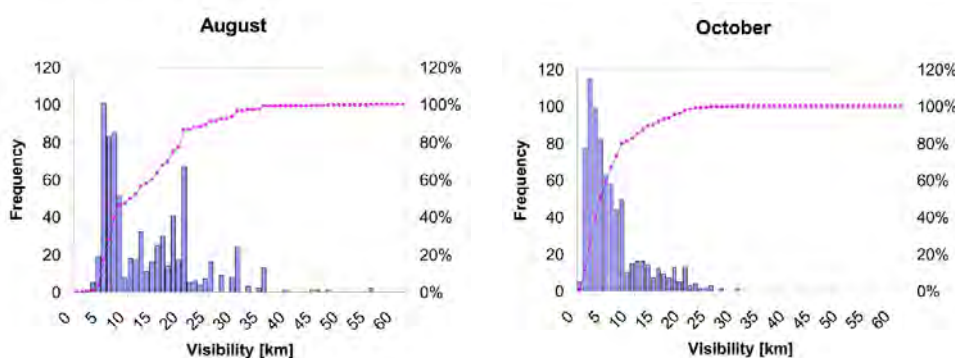
In order to set the maximum value of the atmospheric visibility as the $d_{i,a}$ distance to be used in the following analyses, the visibility value that is surpassed for the 80% of the time was selected. These values are 5,2 km for the August month and 1,6 km for the October month. In particular, it is the value of October that will be used as a lower limit of visibility distance.

5 THE SKYSCRAPER # 1

5.1 DESCRIPTION OF THE TARGET

This new building is the first skyscraper of the city of Turin and is located near the historical city centre where two main streets are crossing and in correspondence of one of the main train station of the city (Porta Susa). The tower has a rectangular shape of 36 x 60 m, with a larger basement. The building is under construction since 2009 and it is now completed at least as regards the building structure and the envelope. The building envelope is mainly glazed (more than 50,000 m2 of glazed envelope area).
The terrain height of the DTM is equal to the value of 244.80 m; the building height was set to 166 m, thus giving the four upper vertexes of the building at a value of 410.80 m. The skyscraper is indicated by four points (the four vertexes) placed at a height of 410.80 m

Fig. 9

5.2 CALCULATION OF THE VISIBILITY DISTANCES

For the calculations of the limit visibility distances, the following parameters were selected:
- object size D equal to 79.2 m;
- object size H equal to 146 m;
- visual acuity of 1;
- threshold visual size S of 100 square minutes (uninformed recognition with a contrast of 13%).

The object size D was taken as the diagonal of the rectangular shape, while the object size H is equal to the building height reduced of the height of the surrounding buildings equal to 20 m.

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The previous assumptions give a limit visibility distance for the visual acuity $d_{l,v}$ of 272 km and a limit visibility distance for the psychological perception $d_{l,p}$ of 37.0 km. Since the lower of these distances is greater than most of the visibility distances for atmospheric extinction (see Figure 7), for such building it is merely always the atmospheric visibility that limits the visual detection.

5.3 VISIBILITY MAPS

In the following Figures 10 and 11 the visibility maps obtained with a visibility distance of 20 km and with a visibility distance of 1,6 km are reported. These visibility maps are cumulative viewsheds, determined using raster algebra and summing up the results of the visibility for each of the four points of visibility into which the skyscraper was discretized.

It can be seen that in the clear air best case condition, the building will be seen from the vast majority of the city, especially in the neighborhood where green parks areas alternate to blocks of development. This may be already verified today by a specific survey because the building is completed.

In order to give a quantitative evaluation of the visibility of the skyscraper, from the visibility map of Figure 10 the percentage of streets that falls within the visible set was calculated. This was done considering the fact that the urban landscape is visible by people walking in the streets, and that parameter can be of interest in order to determine how much this new landmark building is visible or not. From the analyses conducted on the shape files of streets, the total area of streets (which considers streets as well as yards) amounts at 2,575,802 m² (about 2% of the city surface). Using raster algebra on streets and visibility layers, it was calculated that 799,142 m² see at least one point of the skyscraper. In percentage terms, this means that – in good atmospheric visibility conditions – 31 % of the streets of the city of Turin are seeing this building.

Fig. 10 and Fig. 11

6   THE SKYSCRAPER # 2

6.1 DESCRIPTION OF THE TARGET

This skyscraper has a square building shape of 45 m of side and is designed in the south of the city of Turin, near a railway station and a large tertiary district that was before the largest factory in Turin (Lingotto area). Once completed, this skyscraper will be the highest in Italy, including 42 floors, two of them underfloor: at the 43rd floor there will be a wooden roof open to the public. The project has been amended several times,

bringing the initial height of 220 m to the final value of 210 m. On the facades 1,000 m² of photovoltaic panels are going to be installed in order to ensure, as much as possible, the energy production of the building. The large windows construction is made to reduce the need for artificial lighting. The total land area on which the skyscraper is going to be built is approximately 70,000 m²; around 60,000 m² of retail space are expected in order to develop of this urban district. This project is also connected with another residential district for approx 5,000 inhabitants and a new railway station (Lingotto) with a bridge structure that will connect the current the station to the skyscraper.

The terrain height of the DTM is equal to the value of 234.50 m; the building height was set to 210 m, thus giving the four upper vertexes of the building at a value of 444.50 m. The skyscraper is indicated by four points (the four vertexes) placed at a height of 444.50 m.
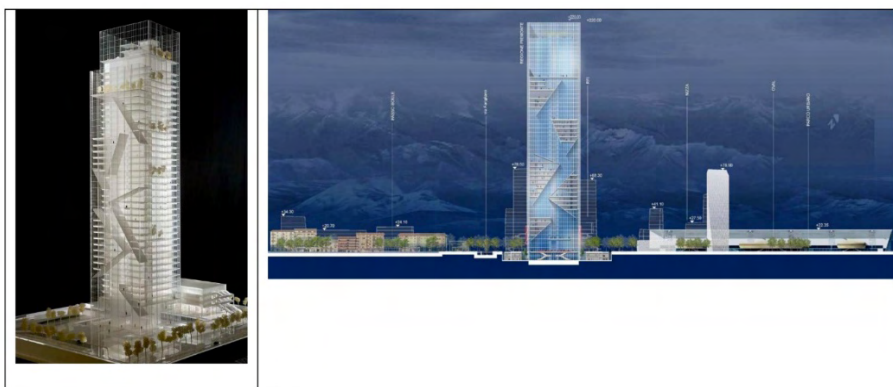
Fig.12.

6.2 CALCULATION OF THE VISIBILITY DISTANCES

For the calculations of the limit visibility distances, the following parameters were selected:

— object size D equal to 63.6 m;

— object size H equal to 190 m;

— visual acuity of 1;

— threshold visual size S of 100 square minutes (uninformed recognition with a contrast of 13%).

The object size D was taken as the diagonal of the square of 45 m, while the object size H is equal to the building height reduced of the height of the surrounding buildings equal to 20 m.

The previous assumptions give a limit visibility distance for the visual acuity $d_{l,v}$ of 218 km and a limit visibility distance for the psychological perception $d_{l,p}$ of 37.8 km. Since the lower of these distances is greater than most of the visibility distances for atmospheric extinction (see Figure 7), for such building it is merely always the atmospheric visibility, with its continuous variation of the visibility distance as a function of the meteorological conditions, that limits the visual detection.

6.3 VISIBILITY MAPS

In the following Figures 13 and 14 the visibility maps obtained with a visibility distance of 20 km and with a visibility distance of 1,6 km, as discussed in paragraph 4.4. Again, these visibility maps are cumulative viewsheds, determined using raster algebra and summing up the results of the visibility for each of the four points of visibility into which the skyscraper was discretized. In order to give a quantitative evaluation of the visibility of the skyscraper, from the visibility map of Figure 13 the percentage of streets that falls within the visible set was calculated. This was done considering the fact that the urban landscape is visible by people

walking in the streets, and that parameter can be of interest in order to determine how much this new landmark building is visible or no. From the analyses conducted on the shape files of streets, the total area of streets (which considers streets as well as yards) amounts at 2,575,802 m² (about 2% of the city surface). Using raster algebra on streets and visibility layers, it was calculated that 819,316 m² see at least one point of the skyscraper. In percentage terms, this means that – in good atmospheric visibility conditions – 32 % of the streets of the city of Turin will see the new building. As can be seen from Figure 14 these areas may also be far from the skyscraper itself, which is located in the south sector of the city. An analysis on the other neighbouring municipalities should be done in order to ascertain to what degree the building is seen from the municipalities that are placed at the south of the city of Turin.
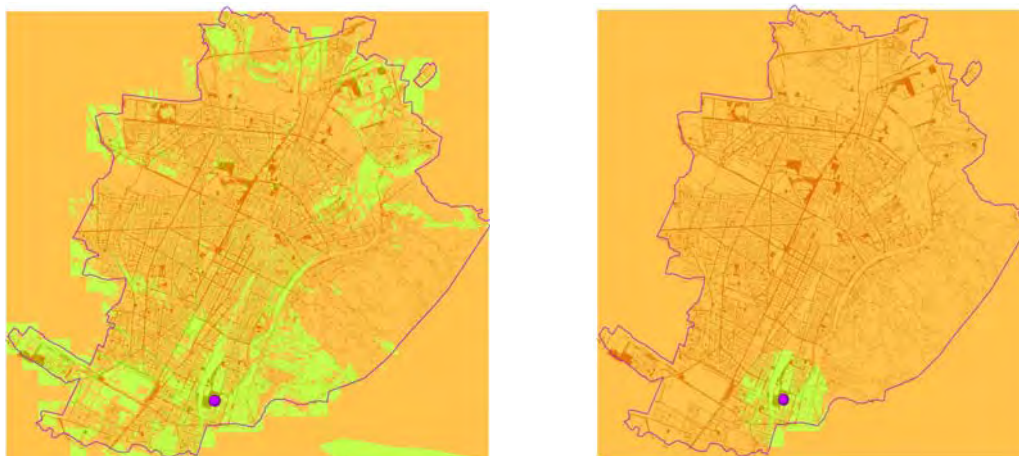

Fig. 13 and Fig. 14

7   CONCLUSIONS

The visibility analysis for urban environment was conducted on the study area of the city of Turin, one of the largest cities of the North-West of Italy. This procedure can become a shared methodology for landscape analyses, integrating both terrain and building models, that are now particularly considered in EIA procedures. A knowledge that is not qualitative but objective may be incorporated into the design process, in order to suggest improvements and corrections in the visual impact analysis and in the mitigation measures, in particular for a city like Turin where two new skyscrapers are under construction and many others are under design. A skyscraper, in fact, is an objects that, by its nature, cannot completely be mitigated from the point of view of the visual impact the tools and methodologies here described allow decision-makers and all the community to know how much and in what way the building changes will take effect on the perception of places.

a	apparent diameter	minutes
C	visual contrast	%
d	distance of observation	km
D	(horizontal) object size	m
$d_{l,a}$	limit visibility distance for the atmospheric extinction	km
$d_{l,p}$	limit visibility distance for the psychological perception	km
$d_{l,v}$	limit visibility distance for the visual acuity	km
H	vertical object size	m
S	visual size	square minutes
α	horizontal angle subtended by the target	minutes
β	vertical angle subtended by the target	minutes

Nomenclature

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