

## The use of gis tools in the study of ventilation corridors in Warsaw - the example of frontal area index method.

### The case of Mokotowski ventilation corridor

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#### ABSTRACT

Scientific Project made by the Students Association of Environmental Development, Planning and Management placed on Faculty of Geodesy and Cartography Warsaw University of Technology is a dissertation concerning the influence of different types of land use on the efficiency of ventilation corridors. This part of project presents an extensive study of urban ventilation using the model of roughness parameter created with frontal area index ratio and GIS tools. The local climate in Warsaw is greatly influenced by existing ventilation corridors and the urban morphology, including high buildings, green spaces, wide streets and infrastructure. Mokotowski Ventilation Corridor is the most important for Warsaw's aeration, because it is the only one, which delivers fresh air from suburbs to the center of Warsaw. During last 20 years the area of the corridor and its overall efficiency has changed dramatically because of the location of new developments.

#### INTRODUCTION

Ventilation corridors are important elements of the urban system of greenery. They are referred as green parts of the city, through which fresh air can get from the suburbs to the city centre. It could be also done in a special areas characterized by a lack of development, like wide streets or airport areas. In ventilation corridors airflow is easier and faster, especially during windy weather.

The idea of ventilation corridors origins from "The sketch of the Regulatory Plan of Warsaw" from 1916. In this document there were proposals to improve the hygienic conditions of the city by creating the system of green areas, parks and greenways connecting the city with areas outside. In subsequent editions of the local development plans the idea of system was improved and evolved until 1992, when it acquired the name of the Warsaw's Exchange and Regeneration Air System. Warsaw ventilation corridors system functioned properly until the 90's of the last century. In 1995 changes in act about protection of agricultural and forest land situated within the administrative boundaries of cities entered. From that time this types of landcover were ceased to be protected. This resulted in the possibility of building on previously open areas. Despite its great value to the natural system of Warsaw, green ventilation corridors are also valuable for investors, who try to reuse them for housing development.

Creating aeration corridors in the city, their maintenance and protection are necessary in fact of increasing housing density and traffic volume, which interrupt free and natural flow of the wind. Mokotowski Ventilation Corridor is the most important for Warsaw's aeration, because it is the only one, which delivers fresh air from suburbs to the center of Warsaw. (Figure 1).



Figure 1: Extent of Mokotowski Ventilation Corridor.

## METHODS

Assumptions and methodology recreated for this project have been already used in scientific studies in Hongkong by Wang (1,2). In those studies frontal area index ratio was described as the total area of the facets of buildings referred to the certain surface - test plot. In practice this ratio is expressed by the ratio of the wall surface exposed to the wind from a certain direction to the reference surface chosen previously (Figure 2). The value of ratio starts from 0 up to 1, which symbolize area, where wind flow is blocked with 100% by buildings situated along its way.

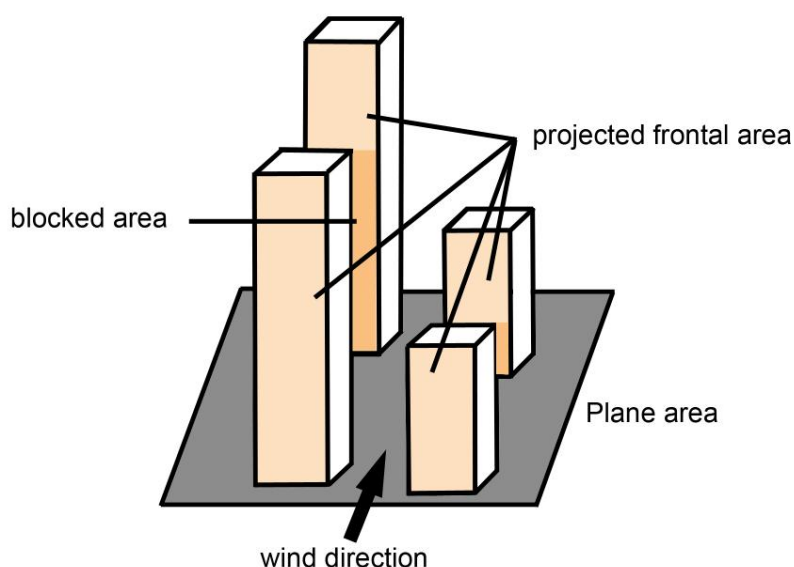


Figure 2: Graphical idea of frontal area index ratio.

Source: Wong M. S., Nichol J. E., To P. H., Wang J. 2010. A simple method for designation of urban ventilation corridors and its application to urban heat island analysis. *Building and Environment*, 45: 1881

The most important cause of using frontal area index method in this project was to indicate the architectural barriers in Mokotowski Ventilation Corridor in 2002 and 2012. The greatest importance to the airflow of this corridor has the southern wind direction. Analyses and visualisations of the results were performed using ArcGIS software - ArcMap and ArcGlobe. The input data for the first analysis were the layer of buildings from the Database of Topographic Objects acquired for the whole territory of Warsaw and WMS service with orthophotomap of the city. On the basis of orthophotos provided by the WMS service there were vectorized borders of corridor. Unfortunately, due to insufficient data accuracy it was necessary to vectorize borders of residential buildings belonging to the new developments. The next step was setting the attributes of buildings: number of floors [f\_number] and height in meters [height]. For few buildings there were not any information about the height - in that cases missing values were estimated with formula:

$$\text{height} = [\text{f\_number}] * 3$$

where: "3" is the value of mean floor height in meters.

The area of corridor was divided into smaller parts by net, which consisted of grid squares with dimensions of 100m × 100 m each. These squares were a reference surface for investigating the ratio of frontal area index. Within each of the squares there were created lines of external walls of buildings, which were perpendicular to the southern wind direction (Figure 3).



Figure 3: Creating lines of external walls.

For each of the prepared line the height attribute was given, which was compatible with the height of the building the line was representing. During this process the setting was taken into consideration, so as the height of the buildings and the real surface exposed in the wind direction - if there were high buildings standing in front of the lower ones, there were not created height lines for covered buildings.

Last part of the analysis was calculating the surface of the blocking area by multiplying the length of each line by their height and summing these values for a single grid square. Frontal area index ratio was created after dividing obtained sum line values by the reference surface. Each pixel on the map symbolises the basic reference unit - square with dimension 100m × 100m.

## RESULTS

Frontal area index ratio analyses were made two times - for 2002 and 2012 with the use of the same type of input data - buildings layer and ortophotomap. In the area of newly settled buildings were noted the largest values of frontal area index (from 0.16 to 0.32), which in this case is linked closely with the ratio of intensity of development. The analysis therefore showed that the newly introduced buildings had adversely affected the airflow, because they are architectural barriers hindering the influx of fresh air to the downtown of the city. New housings tapered corridors permeability and caused the danger disruption of the corridor (Figure 4, Figure 5).

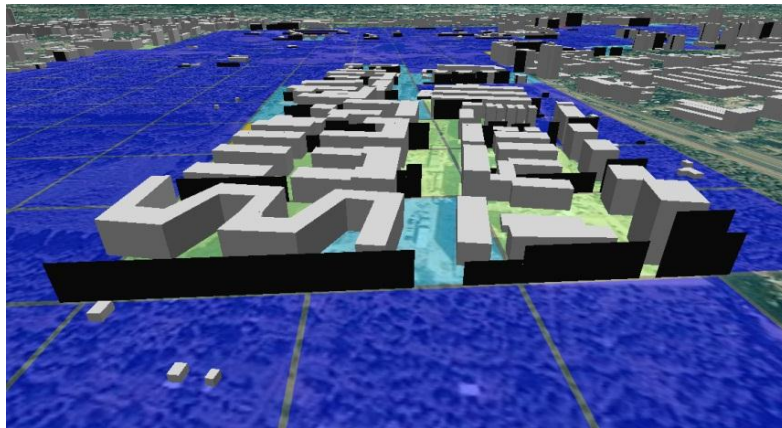


Figure 4: Visualisation of projected frontal area.

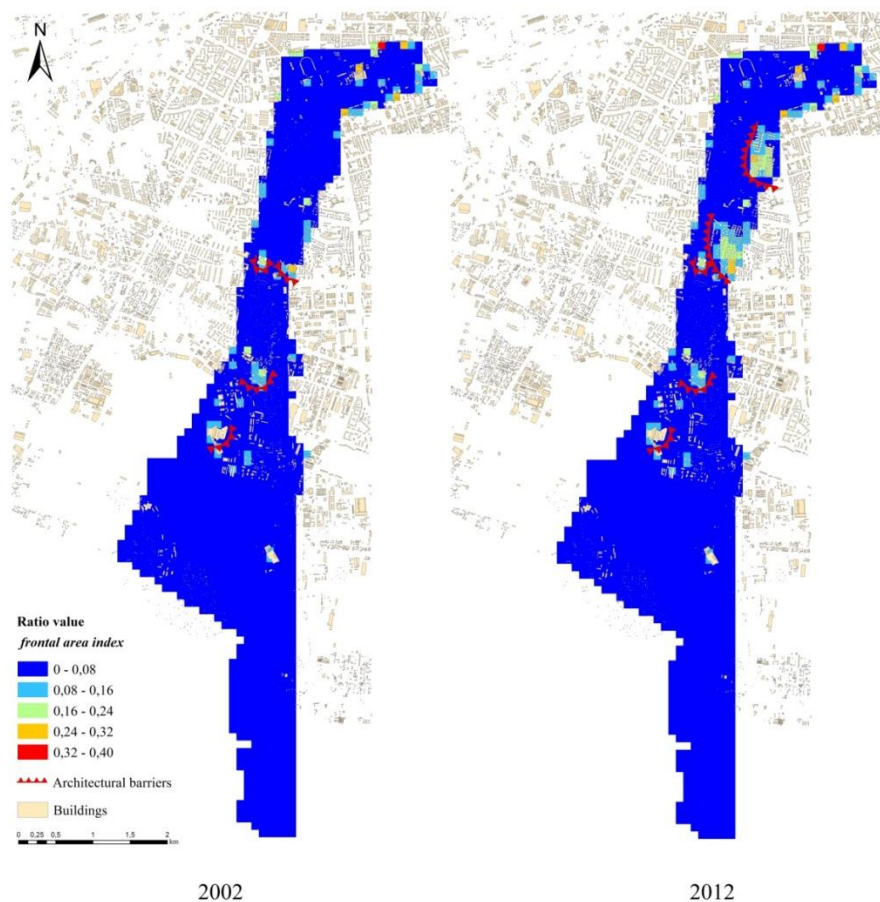


Figure 5: Distribution of frontal area index in Mokotowski Ventilation Corridor.

The results of the analysis made it possible to formulate a set of conclusions about the state of Mokotowski Ventilation Corridor:

- new buildings located in the area of ventilation corridor are barriers for the airflow;
- new developments affect the airflow in the center of the city, changing its direction and reducing speed;
- building settlements interrupted continuity of natural green spaces connecting the suburban areas of greenery inside the city;
- there is a need of stronger law protection of ventilation corridors from new developments.

## CONCLUSIONS

Geographical Information System tools could be effective for making analyses and creating conclusions about efficiency of ventilation corridors. There is a strength validity of the use of GIS technology at various stages of research - from data acquisition (creating thematic spatial databases), data processing (analyses) up to the sharing of research results (in the form of diagrams, drawings, maps and other publications). Future ventilation corridors research will also take into consideration other wind directions and indicators like roughness of the terrain and intensity of development, which are strongly connected with frontal area index. The results of analyses can be used for creating new land development project and corridor's urban renewal conceptions based on relevant orientation of buildings, new forms of greenery and water areas.

## ACKNOWLEDGEMENTS

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## REFERENCES

- 1 Wong M. S., Nichol J. E., To P. H., Wang J. 2010. A simple method for designation of urban ventilation corridors and its application to urban heat island analysis. Building and Environment, 45 (2010): 1880 - 1889
- 2 Wong M. S., Nichol J., Yan-Yung Ng E., Guilbert E., Kwok K. H., To P. H., Wang J. 2010. GIS techniques for mapping urban wind ventilation, using frontal area index and least cost path analysis. International Society for Photogrammetry and Remote Sensing, Proceedings of the Joint International Conference on Theory, Data Handling and Modelling in GeoSpatial Information Science, Volume XXXVIII – Part 2: 586 - 591