Application of DTM in Urban Planning Process to Improve Air Quality

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Introduction

A. Air pollution problem in urban areas:
   - Increasing emission of various types of pollutants.
   - Especially dangerous is particulate matter of a very small size (less than 2.5 μm).
   - Morbidity of asthma and other respiratory diseases increases.

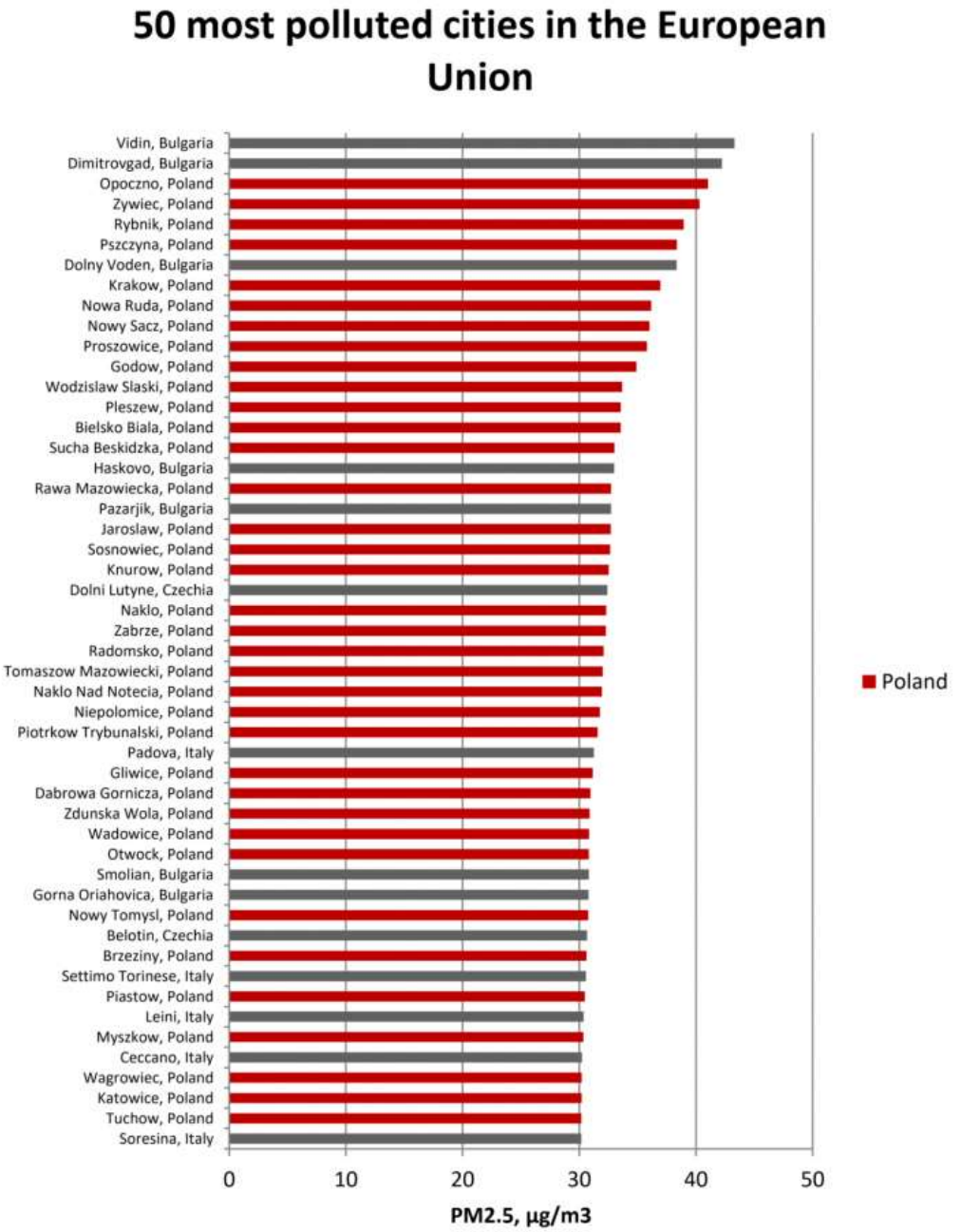
B. Quality of urban air depends on several individual factors:
   - Emission field characteristics.
   - Location.
   - Topography.
   - Meteorology.

C. The influence on the structure of pollutants, their spatial distribution and values have two main factors:
   - Usage of coal as fuel burned for heating used in residential sector.
   - Growing number of motor vehicles on public roads.

A. Reasons for the increased
   - Low quality of the fuel
   - Improper combustion.
   - Outdated or inefficient
   - Lack of proper insulati

B. Type of pollution released:
   - Particulate matter (esp
   - Carbon monoxide.
   - Sulphur oxides.
   - Heavy metals.
   - B(a)P.

C. World Health Organization 50 urban centres in Europe Poland.



Introduction

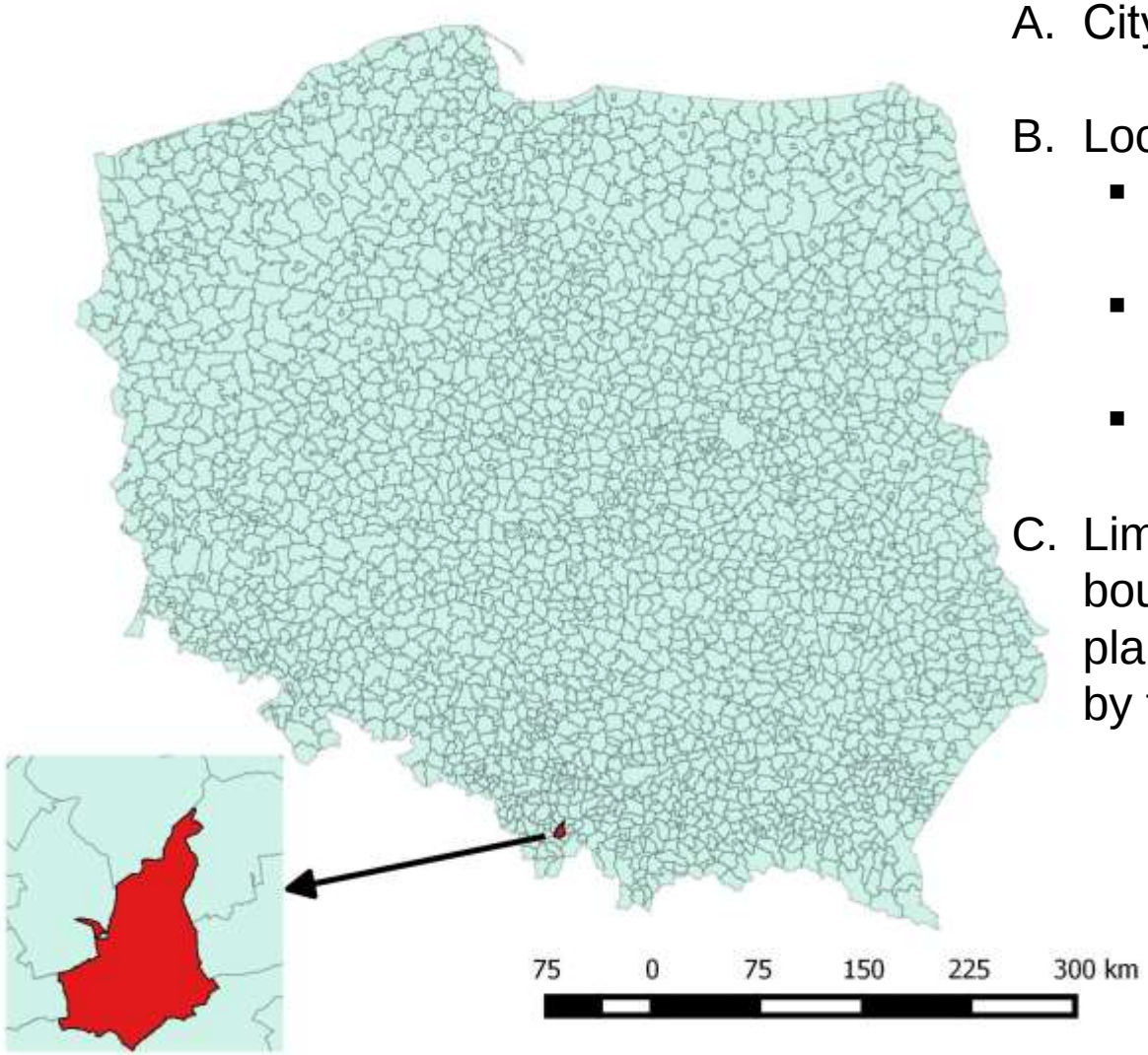
A. Air pollution problem in smaller towns located in mountainous areas:
   - Accumulation of air pollution in the surface layer.
   - Topography affects the movement of pollutants to higher troposphere levels.
   - The concentration of pollutants diminishes considerably with increasing altitude above ground level.
   - Wind speed increases with the altitude above ground level

B. Conclusion: higher situated areas are more favourable from the point of view of the location of buildings, in particular industrial plants.

C. It is important to consider the terrain shape at the stage of planning the development of an urban area.

D. Unfortunately, no such statutory obligation has been introduced.

Study Area



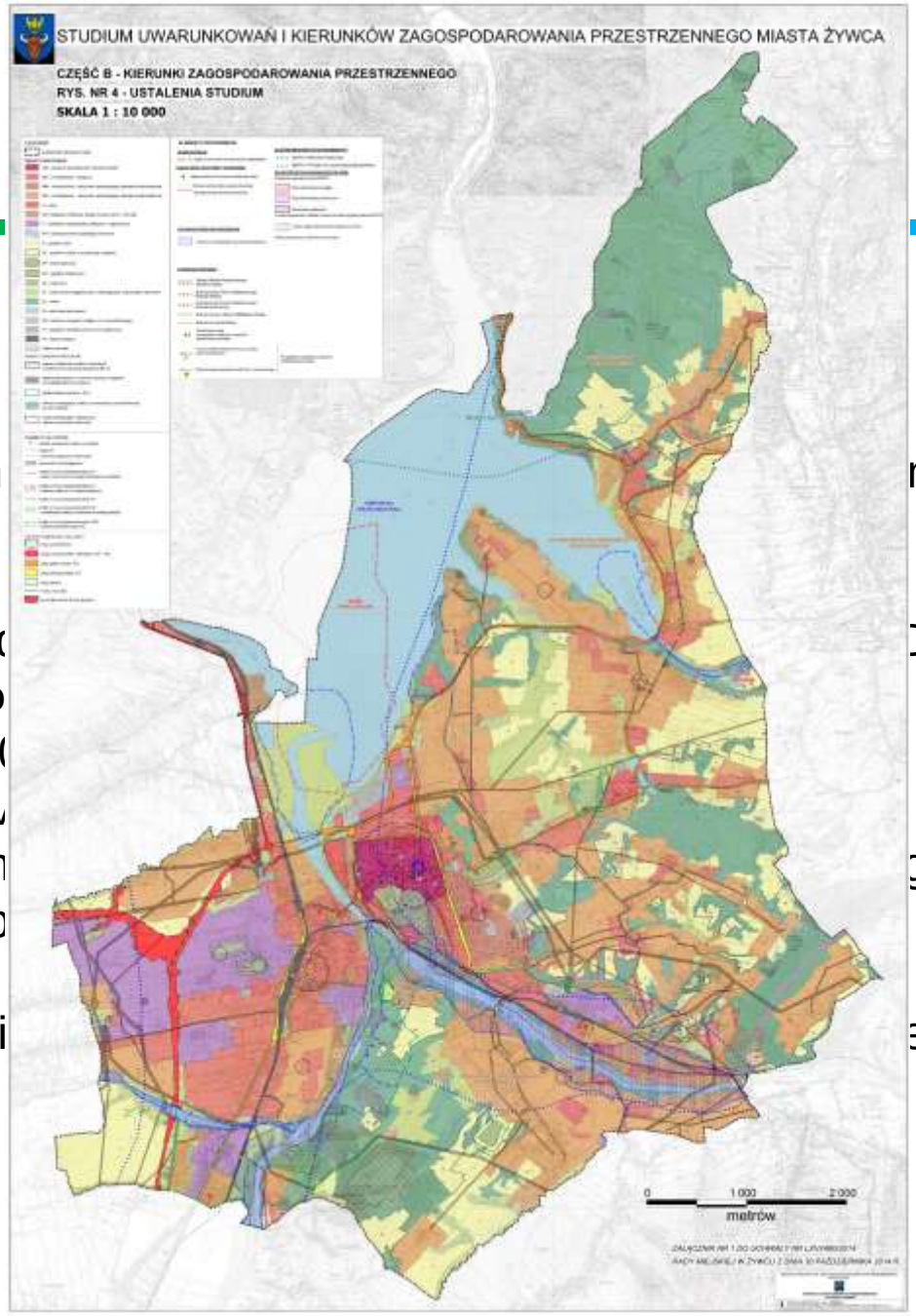
A. City Name: Żywiec

B. Location:
   - Valley of Soła and Koszarawa Rivers.
   - Surrounded by mountain ranges.
   - Very unfavourable.

C. Limitation: administrative boundaries of the City (urban planning document is adopted by the Commune Council)

A. DTM:
   - GRID – interval 100 m.
   - Free of charge.
   - Distributed by the Main nd.

B. Urban planning document:
   - Study of Conditions and D).
   - Adopted by the City Co
   - Date of the adoption: 3(
   - Status: official, public, v
   - Description: contains th g with the spatial develop adopted solutions.
   - Binds municipal authori ent Plans.



Methods
Prerequisites and assumptions

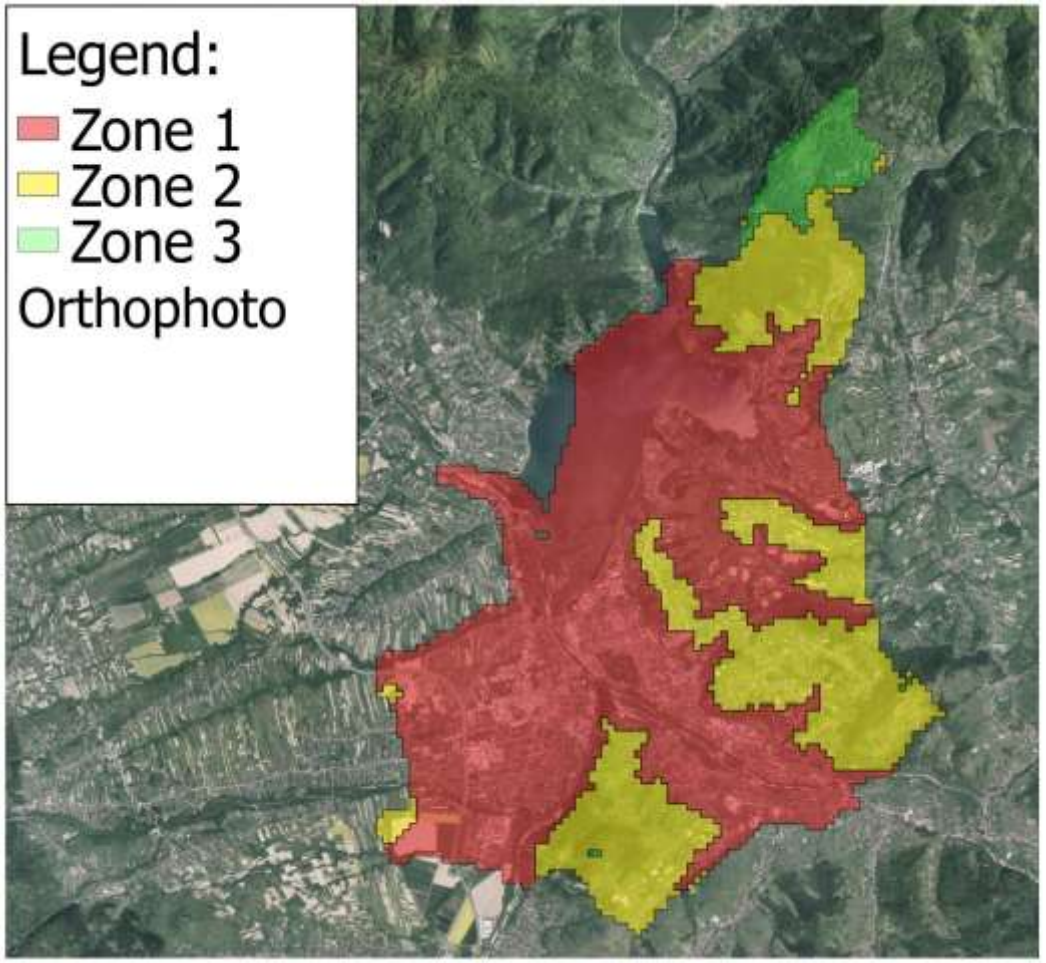
A. Modelling the spread of air pollutants is a very complex issue:
   - The choice of the prognostic model is crucial in order to properly estimate the propagation of pollutants.
   - Structure and accuracy of the input data (emission, meteorological, topographic, physiographic) is an important source of potential uncertainty of generated forecasts .
   - Analytical description of the processes of pollution spread (transport, dispersion, deposition, physico-chemical changes) introduces an even wider range of uncertainty.

B. Simplified approach has been proposed based on previous studies:
   - Can be successfully applied to any area.
   - No need for expensive and long-lasting process of collecting the necessary data.
   - Enables assessing the potential of possible changes in existing planning documents.
   - Synthetic indicator enabling quantitative evaluation of results

Results
Determining zones based on DTM

A. Research area has been divide
   - Unfavourable (Zone 1).
   - Advantageous (Zone 2).
   - Very favourable (Zone 3).

B. Limit values between zones:
   - Average height calculated grid cells.
   - Arithmetic mean consideri elevation.



Zone number	Zone description	H_{min} [m]	H_{max} [m]
1	unfavourable	338	400
2	advantageous	400	596
3	very favourable	596	853

Table 1. Height range of zones

Results
Analysis of urban planning documents

A. Areas defined on the basis of the Study of Conditions and Directions of Spatial Development:
   - Single-family and multi-family housing, service, hotel, guest house, production, storage and warehouse (Intendent development).
   - Existing development.
   - Arable land and land intended for afforestation (Potential area).

B. Intendent development cover both existing and planned development.

C. Potential areas may be changed for development purposes.
   - Majority of agricultural and intended for forestation land in Zone 2.

D. The major part of planned and existing development is located in areas below the average height (zone 1).

Layer	Zone 1	Zone 2	Zone 3
Existing Development	82.3%	17.6%	0.1%
Intendent Development – Existing Delevopment	78.2%	21.8%	0.0%
Arable Land	49.4%	50.6%	0.0%
Land for Afforestation	28.9%	71.1%	0.0%

Table 2. Distribution of layers in zones

Results
Elevation Planning Potential Index

Synthetic indicator enabling quantitative evaluation of results:

$$EPPI = \frac{A_{a\_23} + A_{af\_23}}{A_{d\_1} - A_{e\_1}} * 100\%$$

EPPI	Elevation Planning Potential Index
A_{a_23}	Area of arable land in zone 2 and 3
A_{af_23}	Area of land for afforestation in zone 2 and 3
A_{d_1}	Area intended for development in zone 1
A_{e_1}	Area of existing development in zone 1

EPPI = 26.6%

The scope of potential changes is quite wide.

Conclusion

A. Empirical studies have shown that the wind force is proportional to the height above the ground level.

B. Wind is an important factor that contributes to the faster dispersion of air pollution generated by the combustion of fuels for heating purposes.

C. The work focused on towns located in mountainous areas and proposed a method for assessing existing planning documents from the point of view of introducing changes to improve dispersion of pollution.

D. Current provisions of Polish law do not impose an obligation to take into account terrain elevation in spatial planning.

Conclusion

E. Most of the built-up areas and areas designated for development are located in areas below the average height.

F. Established Elevation Planning Potential Index allows to obtain a quantitative evaluation of the results to identify the potential of eventual changes in existing planning documents.

G. Algorithm can be successfully applied to any area and there is no need for expensive and long-lasting process of collecting the necessary data for estimating the propagation of pollutants.

Thank you

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