

CONCEPT OF DETERMINING THE POTENTIAL OF LAND FOR MULTIFAMILY HOUSING DEVELOPMENT IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT – CASE STUDY OF POLAND

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ABSTRACT

The spatial planning system should be based on the principle of sustainable development. This in turn should lead to spatial order. The article identifies and characterises land requirements for multifamily housing development. The determination of the potential of the land involved adopting key criteria of a spatial, economic, social, and environmental character that predestine land for a given type of development. The established criteria were expertly assigned weights indicating the importance of a given parameter. The concept was tested on the example of the Białołęka district in the city of Warsaw, Poland. The potential of the analysed area was examined in terms of the possibility of development in the scope of multi-family housing with consideration of the concept of sustainable development. The study used multi-criteria spatial analysis. The analyses were carried out based on two methods, namely Weighted Linear Combination (WLC) for fuzzy criteria, and the Boolean method for hard criteria. The obtained results were visualised on a map of investment potential of the study area.

Keywords: land potential, land use, sustainable development, multi-family housing, multi-criteria analysis

INTRODUCTION

As emphasised in international reports, appropriate spatial policy is a driver of sustainable development [1-3]. Sustainable development is defined as socio-economic development involving the process of integration of political, economic, and social activities, with maintenance of environmental balance and stability of the basic environmental processes, to guarantee the possibility of meeting the basic needs of particular communities or citizens of both the modern and future generations [4]. Several dimensions have been identified in the concept of sustainable development: social [5], economic [6-7], spatial [8-10], and environmental [11-13]. Numerous studies regarding the issue of sustainable development therefore emphasise that spatial order is developed by a system of strategic goals with environmental, social, economic, and spatial character [14-15]. They stress that the traditional tools of spatial planning require urgent supplementation with new tools based on information helpful in the understanding of the increasing complexity of land and its continuous evolution and transformations [16]. An intelligent spatial planning system should be based on analyses of large data sets providing a considerably broader and multifaceted scope of knowledge in comparison to the traditional approach to planning [17]. Such activities require multi-criteria spatial analyses, broadly applicable in decision-making processes in a variety of fields [18-20]. In most general terms, spatial analyses that consider a set of criteria in decision making may be understood as a process

of combining and processing geographic input data corresponding to the criteria to create a decisions map [21-23].

The article identifies and characterises requirements regarding land in the scope of multi-family housing development in the context of sustainable development. The determination of land potential involved adopting key criteria with spatial, economic, social, and environmental character that predestine land for a given type of development. The article certainly does not exhaust this broad and interdisciplinary issue. It is limited to criteria permitting obtaining current general data. The designated criteria were expertly assigned weights indicating the importance of a given parameter. The concept was tested based on the example of the Białołęka district in the capital city of Warsaw, Poland, through the assessment of the potential of the study area in terms of possibilities of spatial management in the scope of multi-family housing development. The study employed multi-criteria spatial analysis. The analyses were based on two methods, namely WLC (Weighted Linear Combination) for fuzzy criteria, and the Boolean method for hard criteria. The obtained results were visualised on a map of investment potential of the study area.

STUDY AREA, MATERIALS AND METHODS

Study area

The subject of the study was one of the districts of the capital city of Poland, Warsaw. Białołęka is a district in the north-eastern part of Warsaw. It is the city's second largest district, occupying an area of 73.04 km².

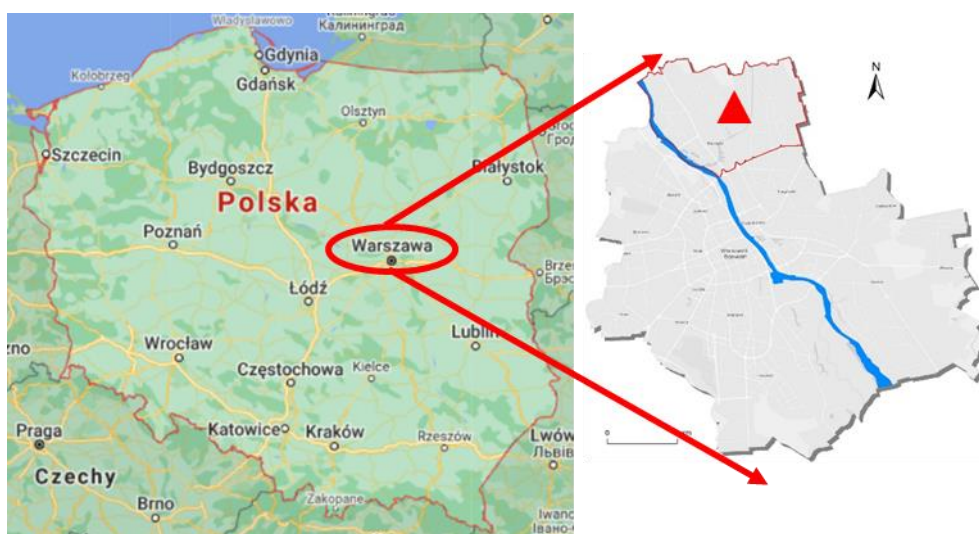


Figure 1. Map of the study area

The population of the district has been systematically growing over the years. The primary factors contributing to the population increase include high natural growth and positive internal and external migration balance. Like other marginal districts, Białołęka is a target of migration of particularly young people from peripheral areas and small towns for continuation of education or job search in the city. People living in the centre of Warsaw often move to such districts due to lower property prices and living costs.

The spatial management of Białołęka has been regulated since 1982, when the General Perspective Plan of spatial management of the capital city of Warsaw was passed. The plan stipulates an evident division between west Białołęka, where land was largely

allocated for building development, and east Białołęka, dominated by agricultural land. Since 1992, the binding document has been the General Local Spatial Management Plan of Warsaw. The plan considered the “expansion” of land with potential for housing development in the western part of the district, and accepted the possibility of urbanisation in its eastern part. Since the turn of the 20th and 21st century, the pro-building development trend in the eastern part of the district has been evident. Since then, new passed plans have been allocating a large proportion of land for building development, including multi-family housing. As at 7 January 2023, Białołęka is covered by local spatial management plans in approximately 43% (3114 ha).

Own analyses conducted based on BDOT10k show that more than half of the area of Białołęka is undeveloped land. The largest share in the management of Białołęka is reached by agricultural areas and meadows (39%). They primarily occur in the eastern part, where arable fields are interspersed by low, dispersed single-family housing. A large area of Białołęka is also occupied by forest land and tree stands (approximately 20%). Built-up land covers more than 26% of the total area of the district. It mainly comprises single-family housing that is dispersed, with clusters particularly predominant in the eastern and northern part of the district. Multi-family housing areas are mainly located in the western and south-eastern part of Białołęka. A considerable share in the development structure is also reached by industrial-warehouse areas. Their occurrence largely stems from the industrial history of Białołęka.

Materials

The designation of the predestination of land towards the transformation of the spatial structure, i.e. determination of the potential of land for multi-family housing development, employed the following data: (i) Data Base of Topographic Objects, (ii) Local spatial management plans in the Białołęka district, (iii) Digital terrain model, (iv) Ecophysiological atlas of the Capital City of Warsaw.

Methods

Multi-criteria analyses were conducted by means of ArcGis software. The implementation of the study objective required obtaining data providing basis for the adjustment of the methodology of multi-criteria analyses, and determination of the assessment criteria. The selection of data is therefore one of the key elements of the analysis. Their appropriate selection, quality, and validity translate into the accuracy of the conducted research.

Areas with conditions most favourable for multi-family housing development were identified by determining land classification criteria with consideration of the objectives of sustainable development and the available data. The following conditions were taken into account:

- social, in the scope of distance from public purpose objects and from industrial and production plants;
- environmental, in the scope of land slope and geotechnical conditions of the substrate;
- economic, in the scope of density of public transportation stops and density of public roads;
- spatial, in the scope of the already existing land allocation in local legal documents, and distance from multi-family housing.

The analyses were conducted by means of the hard and soft method, i.e. the Boolean method and weighted linear combination (WLC). The Boolean method involved

verification of values of all criteria for binary maps in zero and one form, where 0 value denotes an unsuitable area, and 1 – a suitable area. The linear weight method involves standardisation of criteria to a continuous suitability scale in a range from 0 to 255, where zero means the least suitable area, and 255 – the most suitable area. Unlike in the case of the Boolean method, the result is not classified to one of the groups – suitable or unsuitable, but determines the degree of suitability.

The necessary stage of the analysis was ascribing weights to particular criteria. The hierarchy of importance of criteria has a considerable effect on the analysis result. The weight values should therefore be carefully designated. For the purposes of this article, the weights were determined based on knowledge from the literature on the subject, interviews with participants of the real-estate market, and own knowledge and experience.

CRITERIA OF LAND CLASSIFICATION

Due to the adopted research methodology based on the use of multi-criteria analysis for the investigation of the potential of land in the Białoleka district in the scope of multi-family housing development in the context of sustainable development and available data, the following criteria of land classification and their weights were adopted:

1. Distance from public purpose objects (10%).
2. Allocation in local legal documents (20%).
3. Distance from multi-family housing (20%).
4. Distance from industrial and production plants (5%).
5. Density of public transportation stops (15%).
6. Density of public roads (15%).
7. Land slope (10%).
8. Geotechnical conditions of the ground (5%).

Criterion 1. Distance from public purpose objects

Public purpose objects are important places on the city map. The most important public purpose objects include among others: buildings for public administration, administration of justice, education, higher education, or health care. The availability and vicinity of these institutions are desirable for the proper functioning of the community. Figure 2 presents land suitability by distance from public purpose buildings – the closer to such an object, the more attractive the land is.

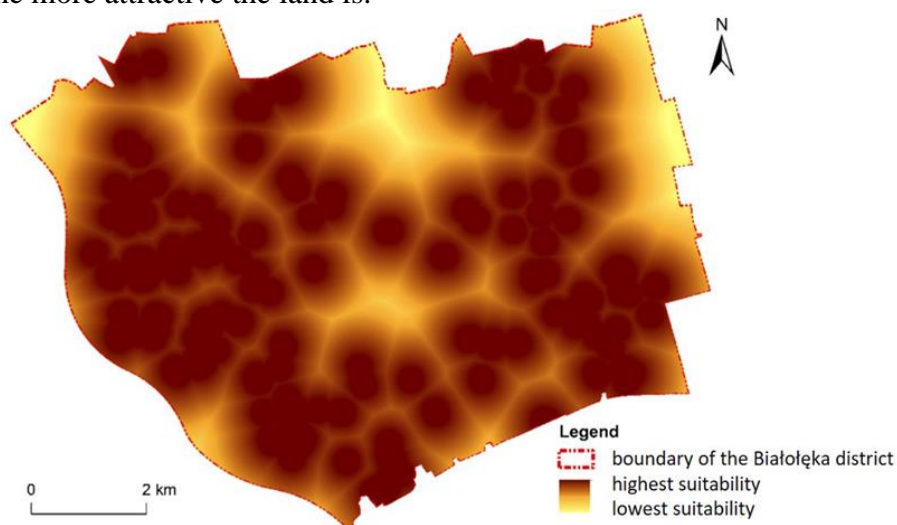


Figure 2. Land suitability by distance from public purpose objects

Criterion 2. Allocation in local legal documents

The local plan provides the basis for spatial planning and directly affects the purpose and conditions of land management, and therefore the potential of land for multi-family housing development investment. In the plan, land allocated for potential implementation of multi-family housing development is marked as suitable, and the remaining land allocated for another form of development or not covered by the local plan – as unsuitable.

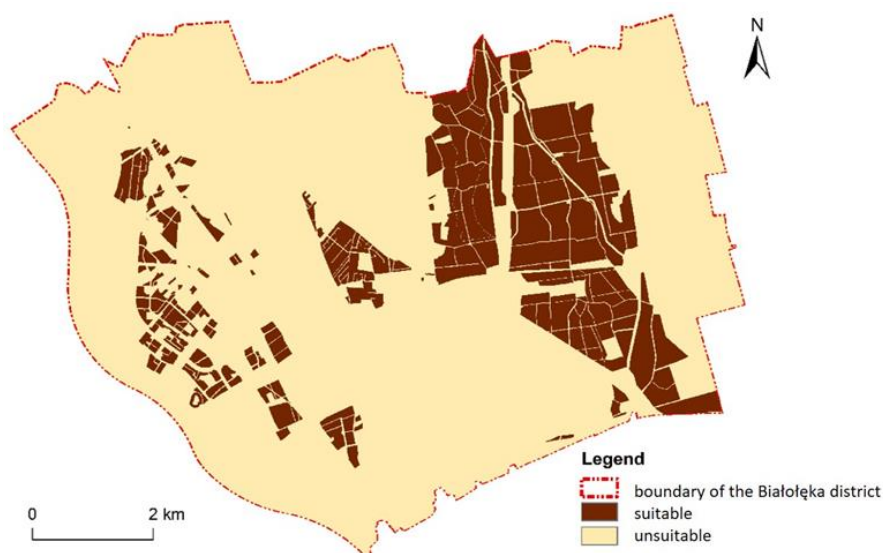


Figure 3. Land suitability by allocation in local legal documents

Criterion 3. Distance from multi-family housing

In the case of lack of the local spatial management plan in a given area, the conditions of building development are determined by an administrative decision issued on request of the investor, i.e. decision on the conditions of building development. One of the conditions of obtaining the decision is the application of the so-called rule of good neighbourhood in the context of the existing building development and networks of utility lines. The analysis deemed land at a distance of up to 150 m from the existing multi-family housing suitable, whereas the smaller the distance, the better.

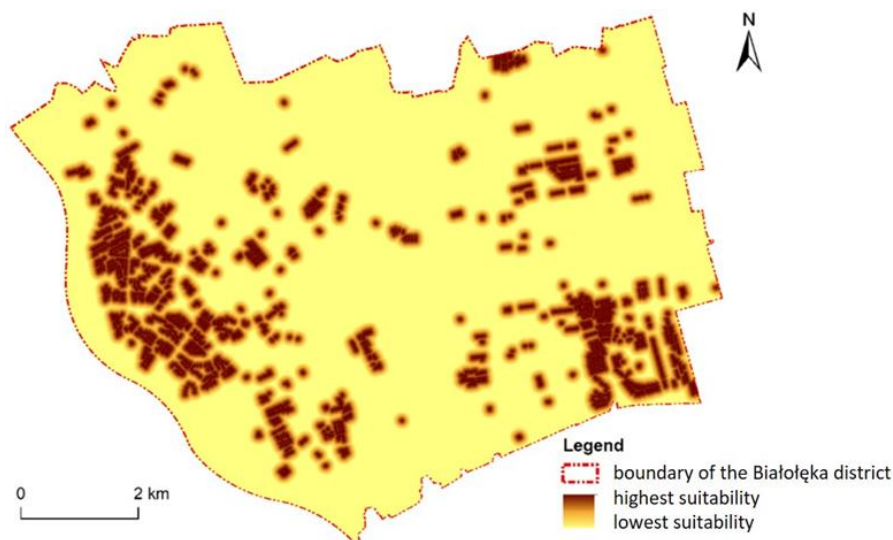


Figure 4. Land suitability by distance from housing

Criterion 4. Distance from industrial and production plants

Due to the previous industrial character of the district, the area of modern Białoleka includes many industrial as well as production and postproduction plants. The presence of such objects in the neighbourhood of building development is commonly socially undesirable. It decreases the attractiveness of the land. The analysis involved the demarcation of areas at a distance of up to 100 m from production and industrial plants as unsuitable, and those at a higher distance as suitable.

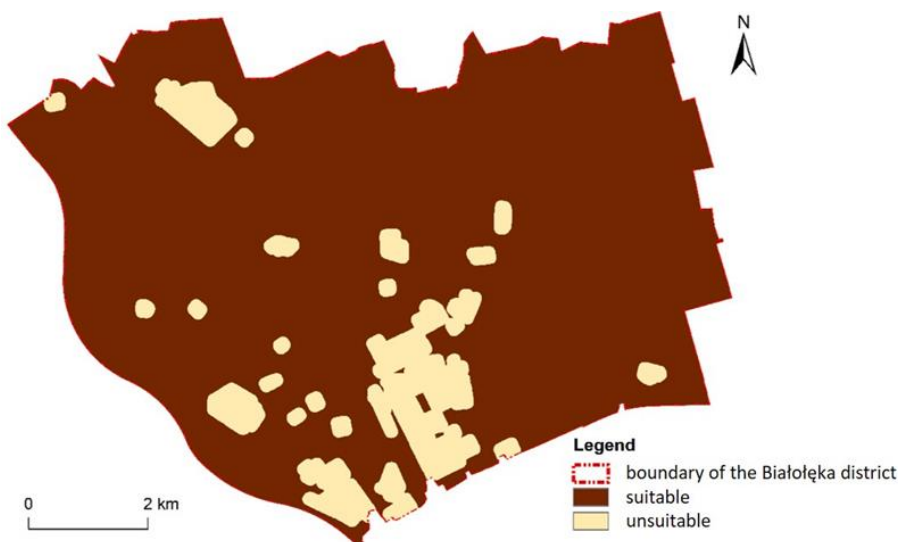


Figure 5. Land suitability by distance from industrial, production, and postproduction plants

Criterion 5. Density of public transportation stops

Vicinity of public transportation stops is key in the context of decisions of potential purchasers of apartments. A small distance from collective transportation stops offers the possibility of fast commute, and an alternative for car travel.

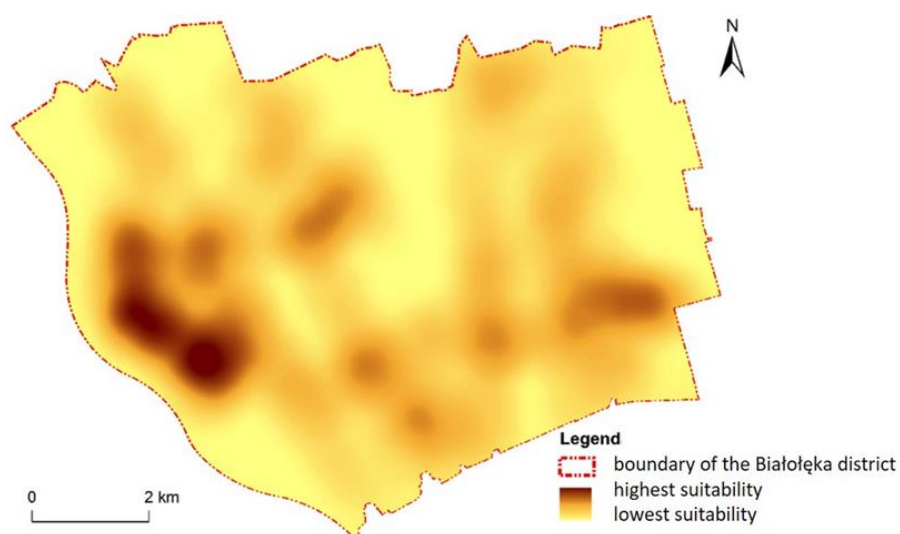


Figure 6. Land suitability by density of public transportation stops

Criterion 6. Density of public roads

Land located directly at a public road does not require the investor to build new access roads to the planned investment. Therefore, it does not increase the financial expenditure, or “take” the building space. For a resident, purchasing an apartment near the already existing roads is important due to the better developed technical and transport infrastructure at main roads, and due to the vicinity of various services.

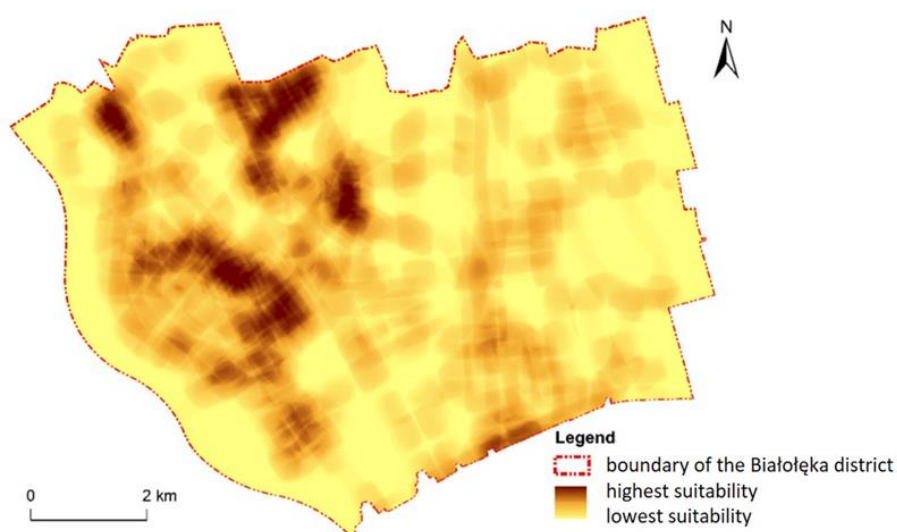


Figure 7. Land suitability by density of public roads

Criterion 7. Land slope

In the case of planning an investment, land relief is an important factor in decision making regarding the location of housing development. Situating buildings on land with a steep slope generates additional costs related to among others surface levelling for the investment. By land slope, the suitability of land for building development can be classified as follows: (i) slope $0-3^\circ$ – land suitable for unlimited building development, (ii) slope $3-5^\circ$ – land suitable for building development with restrictions of after

adaptation, (iii) slope above 5° – land unsuitable for building development [24]. The analysis deemed land with a slope of up to 5° suitable for building development, whereas the smallest the slope the better.

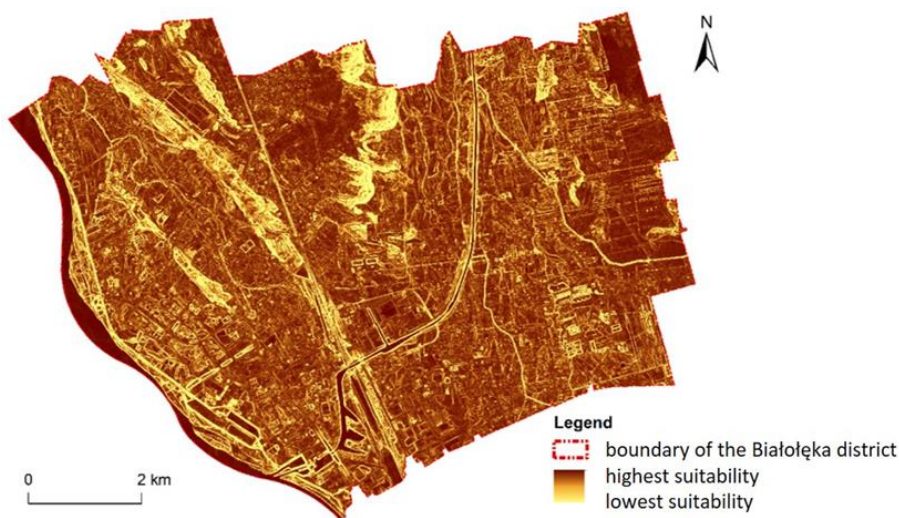


Figure 8. Land suitability by land slope

Criterion 8. Geotechnical conditions of the ground

Areas of occurrence of weak bearing ground and shallow groundwaters, as well as other soil conditions unfavourable for building development are particularly problematic. Some of the areas require advanced ground works to become suitable for building development. It requires incurring additional financial costs. The following were classified in the district: (i) weak bearing ground, (ii) anthropogenic ground with a thickness of more than 1.0 m, (iii) ground with an aquifer up to 2.0 m b.g.l., (iv) wetlands. They were marked as unsuitable in the analysis.

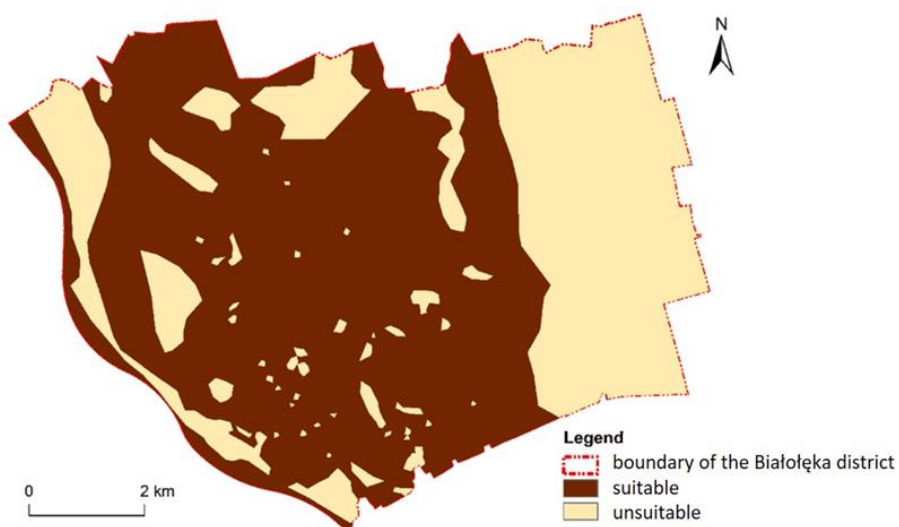


Figure 9. Land suitability by geotechnical ground conditions

RESULTS AND DISCUSSION

As a result of implementation of particular criteria, eight rasters were developed. They were then combined into a single resulting raster. A map of land suitability for multi-family housing development was obtained. Green colour visualises land with greater suitability, and brown colour land with the lowest suitability. The most suitable land is primarily located in the western and south-eastern part of the district. The analysis shows that areas with the lowest degree of suitability are concentrated along the Vistula River (western boundary of the district), in forest areas in the northern part of Białoleka, in the area of industrial complexes in the central-southern part of the district, and in its eastern part, characterised by weaker geotechnical ground conditions.

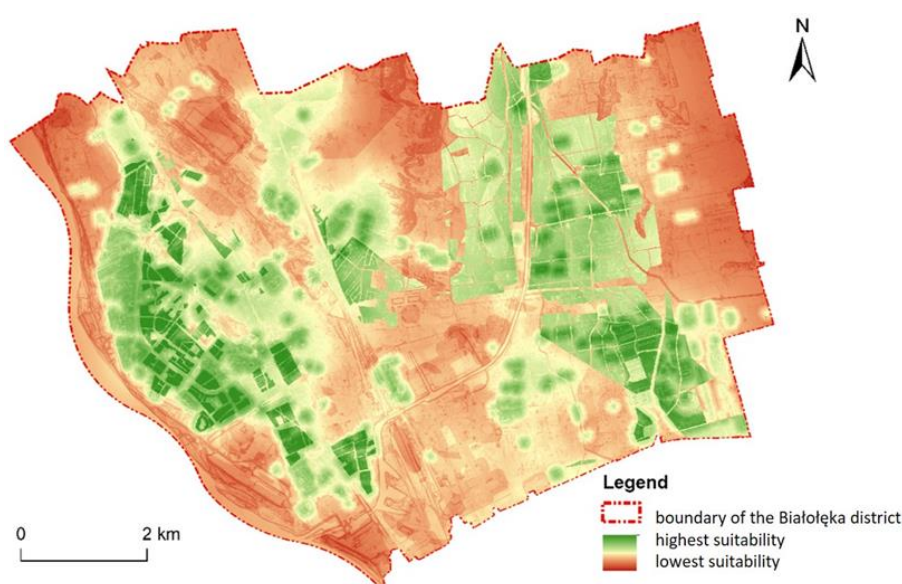


Figure 10. Land suitability for multi-family housing development

The assessment of the actual potential of land required the development of so-called exclusion mask, i.e. designation of areas where multi-family housing development is not possible. It was assumed that the limitations result from another land purpose in local spatial management plans and twelve layers of the base of topographic objects (BDOT10k), i.e. 1. sports structures, 2. cemetery structures, 3. technical structures, 4. other structures, 5. built-up areas, 6. surface water areas, 7. forest areas and tree stands, 8. permanent cultivation areas, 9. protected areas, 10. transportation and transportation service areas, 11. waste dumps, 12. excavations and spoil dumps.

The aforementioned barriers considerably narrowed down the area predestined for multi-family housing development. The final map of land suitability shows a general deficit of land for building development in the western part of the district. These areas are fragmented, and most of them show low suitability. In the central-eastern belt of Białoleka, there is, however, a considerable reserve of land where multi-family housing development can be implemented. The land is only partially covered by local spatial management plans permitting the analysed type of building development. The areas, however, require greater investment in technical infrastructure.

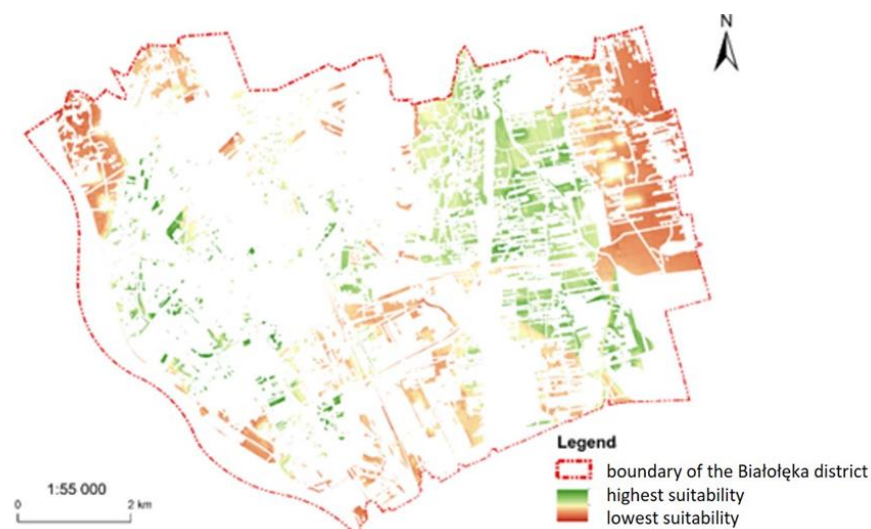


Figure 11. Land suitability for multi-family housing development

CONCLUSIONS

The proposed concept of designation of areas predestined for multi-family housing development is based on the priorities of sustainable development. This means that in the scope of the analysis of land suitability, the criteria of economic (including infrastructure), spatial, and environmental character cannot constitute the exclusive conditions of the choice. Criteria with social character are equally important. The range of criteria itself remains open, and dependent on the availability of data and land specificity.

Sustainable development is synonymous with harmonious growth which taps into the space's full potential through a proper spatial policy conducted by the authorities with the use of planning instruments [25]. Therefore, an effective spatial planning policy should strive to improve the quality of life of residents by eliminating transforming or changing space [26-27]. The application of intelligent solutions should provide the basis for making justified urban planning decisions. The introduced structural and spatial changes should be based on the concept of sustainable development with the application of intelligent methods and tools of development and respect for the social aspects.

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