GIS IN MEDIEVAL ARCHAEOLOGY

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Abstract.

GIS in medieval archeology it is the topic of this paper. The aim of this project is a location of community called Kocanov, which disappeared in the Middle Ages in the ArcGIS and creating a prediction, which is based on characteristics of human activity and their relation to space. Estimation of habitual area of the community in the Middle Ages is based on spatial analysis and presents new opportunities in classical archeology. In this work there are described various procedures of making archaeological prediction model. Formation model is to use the features of the hydrological modeling, the distance from water sources, steep terrain, the visibility of the observed points. Result of the analysis is focused on determining the appropriate settlement location. The resulting localization is compared to historical sources and analyzed using the archaeological works. Interpretation and evaluation of results achieved is the starting point for new opportunities, which would lead to more detailed identification of potential archaeological sites.

Keywords: GIS, archaeology, localization, old maps, prediction model, spatial analysis.

1. INTRODUCTION

Currently, geographic information systems are the main element of a non-destructive approach to the nature of spatial data. Their use in various applied sciences is indispensable nowadays. This may include science

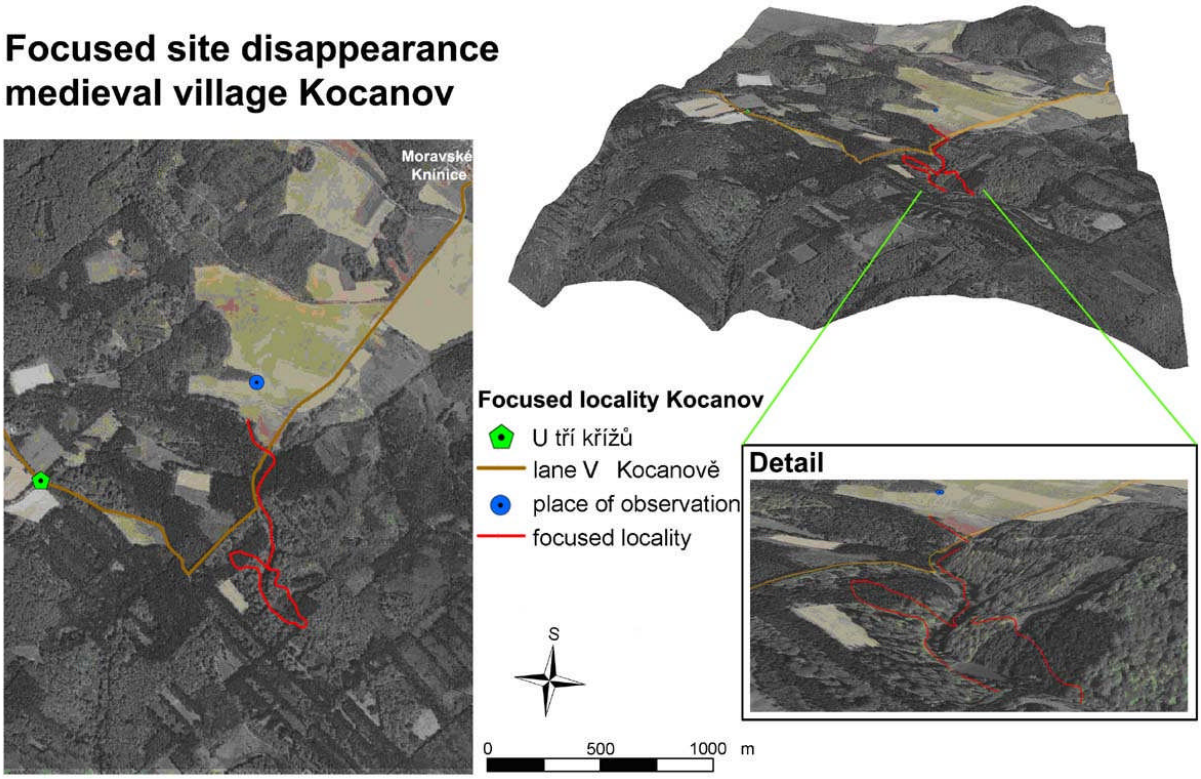

Fig. 1. Overview of the focused locality

and archeology, which work with spatial information associated with historical and contemporary world. The aim of this project is a certain appreciation of the facts as to push the classical archeology at the comprehensive link between past and present world. This work deals with possibilities to link spatial information in GIS environment with archaeological knowledge of the past, such as search and obtain historical and contemporary documents, evaluation of their use for archaeological prediction. The main emphasis is on landscape analysis using GIS spatial analysis and analysis resulting from historical, ethnographic, archaeological and environmental research. The aim is to locate a comprehensive analysis of the defunct medieval villages in the area of Kocanov, Jinačovice set out by municipalities, Moravské Knínice, Chudčice and Rozdrojovice – see Fig. 1. In this paper we deal with verification of each character issue at the site, its archaeological characteristics, reconnaissance, searching for literary documents and map reconstruction. The next part deals with the issue of archaeological prediction model and a procedure for solving spatial analysis. In the final section, we evaluate and interpret the results of tracking a vanished medieval village of Kocanov.

2. CONCEPTION OF THE PREDICTION MODEL

The first attempt to pragmatically oriented archaeological prediction was recorded in American literature [9]. The solution described in the article was inspired by the projects [10] and [11]. Prediction Methods in Archaeology can be divided into inductive and deductive. The inductive method works on the basis of already obtained findings (artifacts). In our case we make use of deductive methods to be used for prediction of the sites without archaeological findings. Conception of the prediction model is depicted in Fig. 2. The results in [10] and [11] confirmed the generally accepted finding that the location of archaeological findings depends on the parameters of the natural environment (especially the distance from the nearest watercourse, slope of terrain, altitude, possibly on the nature of soils). In addition, there is a strong link to the previous history of the country, which reflected in the ideological motivation: residential areas, even after many centuries of avoiding the areas of earlier sites, which must have had some ritual justification. Furthermore, there is the dependence on settlement processes on social factors. All these facts are reflected in the input parameters of the prediction model.

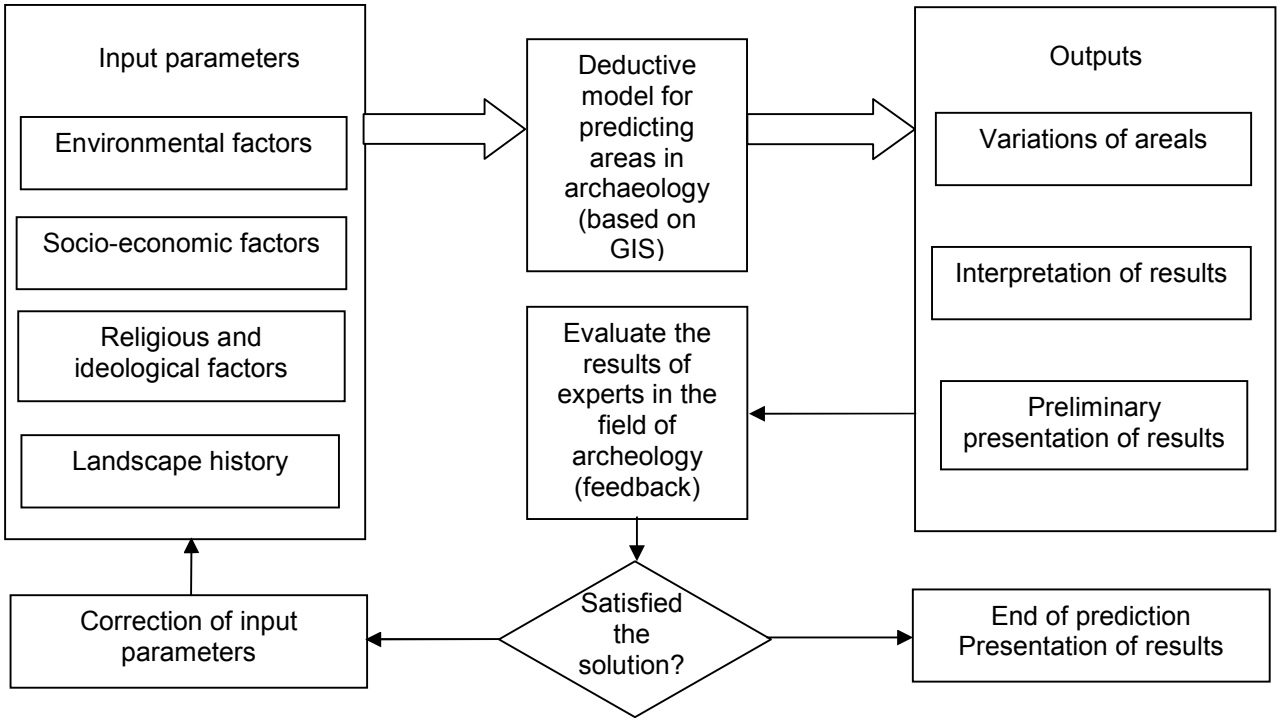

Fig. 2. Conception of the prediction model

All these facts are crucial for the predicting the occurrence of prehistoric sites. If the location of prehistoric sites in addition to the natural environment depends also on the social and ideological factors and the history of the country, then the prediction is obviously difficult, and in some cases even impossible, only the study of natural conditions. It is important to study the relationship of the social dimensions of the settlement areas, determine their structure and history and to make use of GIS tools to achieve these aims. Therefore it has been inserted feedback into the model. Its function is to correct the input parameters of the model. The results obtained by experimenting with the model are tested in the iteration cycle. The test is realized in cooperation with experts in the field of medieval archeology.

3. PREDICTION MODEL DEVELOPMENT

The project was proposed as a simple prediction model for estimating the potential location of the defunct medieval village of Kocanov. Verification with "technically advanced" software is now pushing forward and offering new possibilities in classical archaeology prediction. APM (Archaeological Predictive Modeling) is the goal (objective) of creating a mere prediction associated with the clarification of human activities on the already documented sites and their relation to space [1]. Next, create APM presents a forecast of unexplained deaths estates context. In developing the archaeological prediction model it is necessary to cooperate with archaeologists themselves or to use literature, which deals with archaeological interpretation. It is necessary to consider the contexts associated with certain factors. Among these factors may include the suitability of the environment, economic factor, factor minimum effort, defensive factor etc. For the considered factors there are certain criteria that effectively create prediction model for the implementation of spatial analysis in ArcGIS.

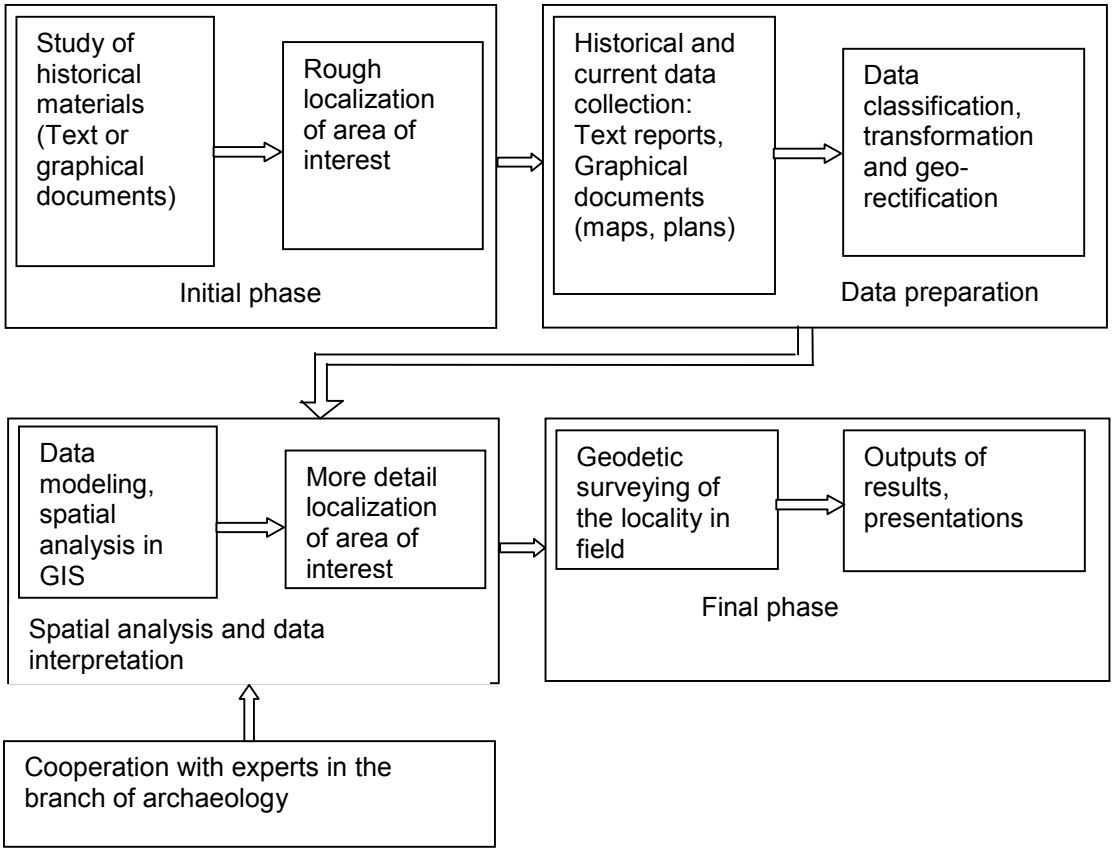

Fig. 3. Development of the prediction model

The whole project consists of 4 phases – see Fig. 3:

1. Initial phase,

2. Data preparation,

3. Spatial analysis and data interpretation,

4. Final phase.

The used model is generalization of methods used in publication [7].

3.1 The initial phase

The aim of this project is to identify the location of the defunct medieval village of Kocanov. Verification of the existence of a medieval settlement today is feasible only with the help of written historical sources; local names in old maps and documents, especially with reproducible, providing archaeological evidence of the site in question [4]. Historical documents from the Middle Ages are preserved only in the form of literary sources. Therefore, the effort was initially focused on the history of a wide area at municipality of Jinačovice, Moravian Kninice, Chudčice, Rozdrojovice later it has concentrated on Kocanov locality. Reconnaissance issue at the site took place on the ground under the supervision of an archaeologist, where each detail has to be in accordance with archaeological practice [5]. The individual sites were compared with historical map data, which are subsequently transformed in ArcGIS for further technical procedures in the field of spatial data analysis. Very important is the study of historical literature. The previous chapter suggests that successful prediction can't be made without clarification of the fundamental questions what we want to predict or expect and then we have at disposal not only environmental factors, but also a number of historical, social and ideological factors.

3.2 Data preparation

Data collection and search are the most important stages of project design for archaeological purposes in ArcGIS environment. Sources of data are essential for building an information system as a prerequisite for spatial analysis. Phase search of suitable substrates is the largest part of the whole work. Among the primary sources may rank surveying, measuring methods of GPS, Remote Sensing (RS), Photogrammetric, etc. The next step includes searching variety of cartographic materials, custom drawings and maps, a database in tabular form, literary, historical text documents, further archaeological and environmental data, data from historical maps, ethnographic research. For the purposes of the project were used both the primary and secondary data sources. Among the evidences supporting archaeological interpretations are primarily historical and ethnographic data. All input data are shown in the Table 1.

When working with the old historical maps we use simple geometric transformations with fewer identical points. The degree of transformation is expressed in polynomial n-th degree. The background raster pixel position is expressed in the system of map coordinates. Geo-referencing process was carried out by using ground control points, which are specific for particular pixel grid coordinates. The quality of input data has been consulted with archaeologists - Archaeological Institute of The Academy of Sciences of the Czech Republic (ASCR), Brno. The low numbers of input data layouts are identical predicting greater emphasis on quality control of data due to the use of rectilinear spatial analysis. Vector bases in the series underwent adjustments which makes it much clearer. Raster documents in digital form are usually created by scanning analogue maps or aerial or satellite acquisition documents, photographic documentation. Most historical documents require the layout type: trimming redundant information, unifying graphic map sheets in the more compact base. All image adjustments were made in Adobe Photoshop Version: 10.0.

Table 1. Input data

Sources	Data source (company)	Datum	Number of sheets	Content	Format
Sources representing spatial features	Czech Office for Surveying and Cadastre	2003	8	Orthophoto	GeoTIFF
		2002	2	Fundamental Base of Geographic Data (3D)	Vector SHP
	Archive of surveying and cadastre	1850-1872	18	Historical maps in the form of mandatory fingerprint scanned imperial stable land of Moravia and Silesia	JPEG
	Military Geography and Hydrometeorology Office, Dobruška	1950,1976	4	aerial survey photos, 8 bit, 1814 dpi	GeoTIFF
Sources representing archaeological features	National Heritage Institute, Brno	2010	1	National Archaeological list of the municipalities a period of prehistory and the Middle Ages, coat areas with archaeological finds	Vector SHP
	Moravian Library, Archaeological Institute of the ASCR (Brno), State District Archive Brno-Country (Rajhrad)	1827-2010	10	loaned archaeological literature	
Sources of the geological character	Research Institute of amelioration and soil conservation, Department of Soil services Brno	2010	1	Digital form a clear map of valuated soil-ecological units at a scale of 1:5000	Vector SHP
	Map Services Public Administration Portal, CENIA	2010	1	Map of potential natural vegetation in Czech Republic	Vector SHP
Source from the climatologically science	Moravian Library	2003	1	Landscape Atlas of the Czech Republic	

3.3 Spatial analysis and data interpretation

The core of the project was to exploit the possibilities of spatial analysis in ArcGIS. Spatial analysis of individual housing estate was realized the area of interest using landscape characteristics (landforms, river system, topographical features of the country). In spatial analysis, there were also taken into account other factors such as environmental suitability, economic factor, factor minimum effort, defensive factor, and the cult factor. An important variable and the time factor were observed, because the country and its components are constantly evolving. Therefore it is not possible to examine clearly the linkages between current environment and the environment in the past. It is necessary to set certain targets in the planning of spatial analysis. The primary objective is to find appropriate combinations of spatial analysis in ArcGIS. Another supreme objective was a comprehensive spatial analysis based on documents obtained by the solving site. It was created a digital terrain model, which was applied to each particular analysis of landscape characteristics (terrain slope, shaded relief, exposure area).The substrate that was used for making DMT (Digital Terrain Model) of a given area was ZABAGED (Fundamental Base of Geographic Data) - digital model derived from the vector map image the Base Map 1:10 000 CR (ZM10). Results of landscape features were used for further spatial analysis procedures.

For the spatial analysis it was used multiobjective modeling. The model makes use of quantitative (calculating the area of polygons, the search space with some acreage) and qualitative criteria (reclassification methods - the process of gradient maps defunct settlement likely in the range 0-7% and 7-90%, buffer zones - distance analysis of type distance to the village 150m, 300m from the water source). It was necessary to take into account certain quantitative and qualitative criteria for the landscape component and settlement in the Middle Ages.

For another archaeological prediction model it was used hydrological modeling on the basis of topographic features (water source in solving - the likelihood of human existence in the Middle Ages). Analyses of field elements using data from the general geomorfometry related to hydrology are beneficial to the procedure of the archaeological prediction model (APM). For analysis the hydrological modeling of river network model the smallest streams were made use of, acting as the confluence of several rivers. Hydrological modeling procedure itself consisted of creating a hydrological correct DMT, where various analyses were performed: determine the direction of runoff, accumulated runoff, drainage network, drainage and river length [2]. As a basis for hydrological modeling was used DMT created raster shapefile on waterways and lakes. At the end of the hydrological modeling criteria we have set distances (buffer zones) from the water source, areas within 300m from the water source and the surface to 150m from the water source.

Any action taken as the process of creating maps of slope and hydrological modeling process of moving towards a targeted location solved vanished medieval village. As a result of finished reclassified layers (buffer zones within 150 meters from the water source of hydrological modeling, gradient maps - used interval gradient to 7%), the individual areas of possible occurrence of a medieval settlement were created.

For the final analysis, which aimed to identify the likely site the defunct village of Kocanov, we set a couple of assumptions and criteria. According to literary sources it was identified a clue that has become a precondition for distance analysis. We set the criterion for the likely location of villages within a distance of 1500 meters from the site “U tří křížů”. Around the centre of the site “U tří křížů” buffer zones gradually after 500, 1000 and 1500m has been created. Then we made a breakthrough packaging zones created with the previous results form the basis of topographic and hydrological modeling. In the next stage of spatial analysis it was used the possibility to analyze the visibility. Parameters for the analysis of visibility were chosen according to historical documents. Function visibility may also prove certain inaccuracies in the determination of medieval housing estate, so the height of the likely sites was put 3 m higher. This reasoning implies the existence of possible watchtowers in these points. When using visual scoring points for the creation of village location it was a problem to find a spot in nature. The settlement has the character of surface area; therefore it was necessary to take into account the visibility “lump settlements” which spread out all sides, so the analysis was performed by visualization of line elements, even though the graphic is shown as a point object (point object due to graphic simplicity).

In conclusion, spatial analysis was conducted which resulted in comprehensive analysis of partial results of previous analysis. This comprehensive analysis can determine the existence of potential sites of medieval villages. Consideration of quantitative and qualitative criteria took place again in the ArcGIS environment. Complying places that set criteria were consulted with the experts in the branch of archaeology. We chose those most likely locations for a medieval village and divided them into two categories. The first category, blue ellipse, contains the most likely area. The second one, yellow ellipse, the area contains less likely area. Graphical representation is shown in Fig. 4. All specified areas requiring personal assessment on the ground by the statements of archaeologists in various literary sources.

The focusing of localized settlement has been implemented by manual GPS apparatus – red line in Fig. 1. Used GPS-type apparatus Trimble Recon GPS XC is rugged field computer with an integrated Compact Flash GPS Pathfinder XC receiver. The device is designed for mobile data collection and updating of GIS.

3.4. The final phase

The goal was a comprehensive analysis of possible off-targeting to verify village of Kocanov technically. In agreement with the leading job site, we revealed solved and decrypt individual verbal descriptions and

statements by archaeologists according to the actual state of the country. Surveying process was preceded by a comprehensive assessment of the conclusions of the analysis in the field. The results of complex analysis can be verified on 3 sites of interest (see Fig. 4 blue oval with serial numbers 1, 2, 3).

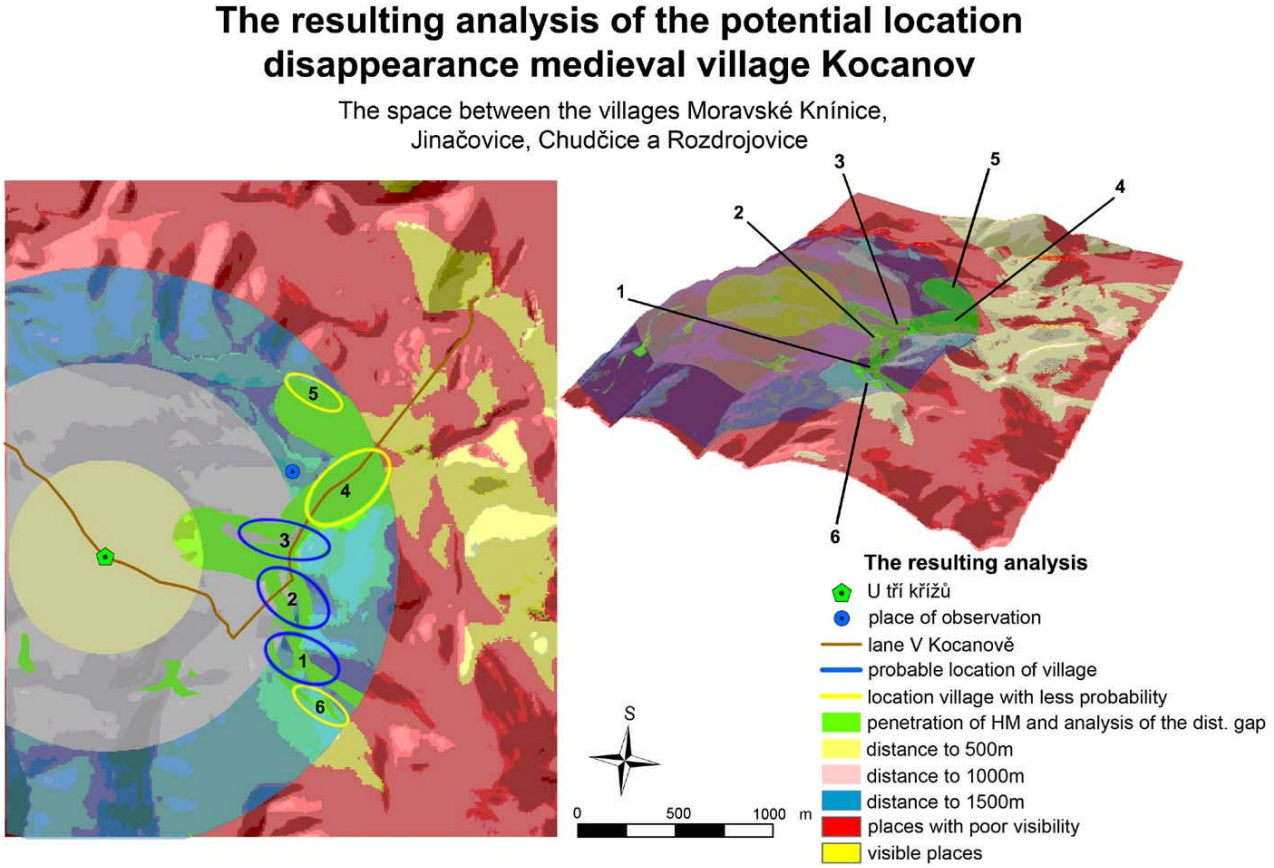

Fig. 4. The result of spatial analysis

Interaction between the general archaeological assumptions medieval village and its incidence is now very important. In conclusion were discussed the connections of results in spatial analysis of landscape elements with factors that follow from historical, ethnographic, archaeological and environmental research. Result of a previous sequence analysis is based on certain assumptions and do not have to be 100% reliable, which declared that the resulting position estimate is certainly right. Therefore in conclusion, we try to assess the mutual ties between the archeological general assumptions of the medieval village and the result of spatial analysis. Peer assessment of spatial analysis and other factors: evaluation of the analysis of topographic and hydrological features, evaluation of the analysis in terms of natural conditions of the territory, evaluation of the analysis of visibility with signs housing development and evaluation of the overall position of the defunct medieval villages.

4. BENEFITS AND FURTHER USE OF THE PROJECT

The work presents new possibilities in classical archaeology and thus science is moved forward into other dimensions. On the project cooperated the Archaeological Institute of the ASCR, further institutions dealing with the history of Brno-country in short companies devoted to archaeology. The project demonstrates the technical diversity of today, which can be used in "non-technical" sciences. We propose a roadmap for implementation of spatial analysis and we have tried different results linked to each other with literary sources and historical documents. For the spatial analysis we took advantage of the hydrological and topographic modeling, which resulted in the analysis of relief. In spatial analysis, we consider some quantitative and qualitative criteria, which were set according to historical documents and archaeological sites. For historical documents we have come close to the location of the village with a retrospective

exhibition of notion of Kocanov municipality [3]. Retrospectively the development of settlements and the formation of cultural landscapes also took place in the ArcGIS environment. To sum up, this project evaluates results of spatial analysis of factors that issue from historical, ethnographic, archaeological and environmental research. Used method demonstrated new possibilities of data collection and analysis to be verified and archaeological objects, whether found or not. Use of ArcGIS extensions can present complex connection between past and present world. Further usage of the project results serve for the purpose of archival video documentation of the Archaeological Institute of the ASCR Brno-country, the historical archive of municipal offices at Jinačovice and Moravské Knínice to be used for the presentation of the history of communities.

5. CONCLUSIONS

Finally, it should also be alerted to the dangers which include prediction methods and to be aware of their usage. Firstly, the results of prediction are probabilistic nature: to warn the increased probability (risk) of archaeological sites, but do not guarantee their presence. Second, areas with a high archaeological potential are not automatically seen as the only interesting part of the archaeological landscape. And outside there may be extremely interesting archaeological information in a way more significant that occur in unexpected places. Therefore forecast maps can not replace the expert's opinion, but they can be useful, both for him and the other users too. We are aware that archaeological prediction lead to a narrowing of the space potential of suspected archaeological sites, not their precise delimitation. Even this narrowing can in practice be significant enough to compensate for the costs embedded in the prediction model. We believe that the proposed project could provide valuable assistance in various spheres of public life, government and business.

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