GIS FOR RELIGIOUS STUDIES

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Abstract
Abbreviation GIS is an equivalent for both science and technology and comes with its own approaches and theories for processing and evaluating various data. Also therefore GIS technologies are currently penetrating various fields of science. This contribution is focused on specific issues connected with application in studies of historical religions within GEHIR project (A Generative Historiography of the Ancient Mediterranean), which is focused mainly on the ancient Mediterranean. Selected issues as nature and properties of historical spatial data, environmental modelling in religious studies etc., will be demonstrated on example of case study dealing with the cult of Isis. Results show potential of GIS for purposes of research studies in the field of the Religious studies.

Keywords: *GIS, Religious studies, Environmental modelling*

INTRODUCTION

Digital humanities are nowadays rising in their popularity in various fields of science. With new methods and technologies scientists are able to produce new findings and outputs in unique forms. The mentioned project of GEHIR (ID MUNI/M/1867/2014) connects researchers from the field of religious studies, information science, mathematics and cartography. The research agenda is to study the spatial and temporal dissemination of different religions in the times of ancient Roman Empire.

This paper tries to introduce a selected issue that lies behind the cartographers that are dealing with historical research. In the next part a case study discovering the spatial reasoning of Egyptian cult's presence in the area of Aegean Sea is described. The following discussion section brings noted issues and questions together and tries to provide recommendations for the related future works.

EXISTING SPATIAL DATASETS AND THEIR CONSTRAINTS

Research in the field of religious studies typically used spatial datasets from different fields of science as archaeology, historiography, etc. Based on the aim of the GEHIR project this paper is focused on the spatial datasets covering ancient Mediterranean.

Pleiades database consists of historical gazetteer built by a community of users. It stores a lot of relevant types of (ancient) places and provides additional information, connection to other places and also a geographic representation. Finally, the project Pelagios is focused on retrieving the datasets from other sources and provides a framework for their visualization. Therefore the essential part is a web map and the ftp repository for those data. Also ORBIS (The Stanford Geospatial Network Model of the Roman World) could be mentioned as it provides the framework for calculation of the cheapest and shortest path between places in ancient Roman Empire.

There are also more specific datasets that should be noted. Project Mantis (The American Numismatic Society) collects information from coins from the times and area of Roman Empire. This dataset has more than 130 000 items and stores

spatial locations, images and other relevant attributes. Similar approach has the project of Heidelberg (Heidelberger Akademie der Wissenschaften) that focuses on epigraphic inscriptions of Roman Empire. Other examples are Fasti (archaeological excavations), the Amphora project (amphoras) or Omnes Viae (Roman roads). Historical datasets should also be used as a proxy, an indirect form for describing a particular phenomenon. This way, the density of amphoras or coins should be used as a proxy for local trade or writing as a proxy for urban expansion.

All these datasets provide specific and valuable insight into a historical period but also their constraints have to be mentioned. Quality of dataset is possible to observe on temporal, thematic (attributional) or spatial level. In our classification, on each of this level, precision, uncertainty and completeness should be defined.

The quality of precision is in lot of cases possible to formalize and stored as an attribute. For example, spatial precision could be classified into categories (i.e. GPS located, literature based location, rough estimation...) and handled in further analysis. Temporal precision is possible to define by the granularity of used units (i.e. days, months, years...) or by the used method (literature, dendrochronology, model...).

Another aspect beside of precision is the uncertainty of a specific historical dataset. For the denomination of complex temporal information historians use terms “ante quem” and “post quem”. These Latin words define the first and last possible occurrence of spectated phenomenon and could be transformed into interval. Length of this interval is then an abstraction for the temporal uncertainty.

In the historical datasets satisfied level completeness is not always guaranteed. In many cases this is a problem of heterogeneous spatial distribution of archaeological excavation or the (sub) regional character of the historical research. This way one historical province could be observed and documented into detail and the neighbouring one only on the global level. Beside the complete absence of particular objects it is possible to observe only the absence of some attributes. In that case these data are not known or the attributes are related only for a subset of data. As these constraints are crucial for the quality of further analyses, the researcher should be informed about them. Then he will be able to choose proper methods and avoid the incorrect output.

METHODOLOGY

As was previously mentioned the project Gehir systematically applies selected methods of formalized modelling and computational simulations to the study of the diffusion dynamics of specific religious ideas and forms of behaviour. In case of geographic information science (GIS), the environmental modelling is a very promising methodological approach originated in Species distribution (e.g. Pearson, 2007) or climate modelling. This approach was also used in historical research. For example Turchin et al (2013) tried to explain how human societies evolved from small groups to huge anonymous societies using environmental modelling.

Therefore we decided to apply this approach for selected case study within the GEHIR project focusing on the spread of the Egyptian cults in the area of Aegean Sea between cca 4th - 2nd century BCE. So far, the historiographical research was mainly based on critical analysis of archaeological evidence and literature. The results from this type of research are put together using researcher's "intuition" and "intuitive predictions". However, when we want to study complex systems with many variables, the computing capacity of human brain and intuition are not simply capable of providing solid results. Modelling and simulations on a network or in geographical space, where the computer guarantees the computational capacity, can be a vital addition to methodological tools of historiography. This methodology can be a vital addition to traditional tools of historiography.

CASE STUDY

Pilot study was conducted on the area of Aegean Sea. The motivation was to reconstruct the process of the spread of the Egyptian cults in that area during the reign of the first Ptolemies (cca 4th - 2nd century BCE). The model can help to explore the correlation between various factors and their possible impact on the cults’ spatial dissemination. Hellenistic Egypt was one of the main exporters of grain and Egyptian goddess Isis was a patron deity of sailors. Also, the first Ptolemies were politically active across the whole ancient Mediterranean (Bricault, 2004; Hölbl, 2001). Therefore, the main research intention was to delimitate the impact of political and trade influences.

From the geographical point of view, the research area consists of tens of islands grouped into two main regions - Dodecanese and Cyclades. Focus was also maintained on other islands that were recognised as potentially crucial for the investigated phenomenon, as Samos and Icaria. Population data for islands were obtained from available historical censi from the end of the eighteen century. Other possible methods and estimations were observed but only mentioned censi were sufficient and relevant for this research.

The first part of research was aimed to prepare an environmental model that could reflect the potential of food shortage on islands. As it could be seen on Fig.1, this model consists of four parts. Firstly, fertile lands are identified based on slope values. Profitability of these lands depends on precipitation and soil types input layers. The area of fertile lands on the particular island multiplied by the island agricultural profitability and given constant value for hectare production is the total island food production. Consumption is then based on island population. The last step is the subtraction of consumption and production values that gives the theoretical surpluses of food reserves.

The next step, the creation of the transportation network was highly inspired by the works of Pascal Arnaud (2005) who collected ancient navigational guides for sailing in the ancient Mediterranean. The standard GIS software was used to redraw all relevant documented maritime routes from literature. Filtered and modified dataset of ancient ports from A de Graauw (2014) was used as a skeleton of our network. The buffers of 100 meters and 2000 meters were created over island geometries as minimal and optimal sailing distances. This zones then determined the construction of routes. Network was afterwards exported to csv format and processed with python and networkX library[8].

This network was used for calculating the distance matrix between all relevant ports. Then the layer of religion evidence (temples, artefacts) and the layer of military activity (military camps, garrisons) were overlapped and identified with the closest port. The distance on network from one port to another with specific phenomenon was used as an abstraction of quantification. For example, the value of distance to the closest port with a temple was used as a parallel of religiosity and the distance to the closest port with a military camp as an impact of army to that island.

As the created network was too complex for basic static analyses, a new simplified network (node = port) was drawn. Then one agent was sent from the port of Alexandria to each existing port and the total sum of all stops was calculated. This was an abstraction and quantification of the strategical advantage of island position in the network. Other recommended measures as eigenvector value or the node degree were not used as they were evaluated as inefficient.

Afterwards, all these collected values were put into one table and possible correlations were observed. Specifically for the given hypothesis - crucial were relations between the distance to the closest temple and the distance to the closest army, potential of food shortage or used centrality value. In the first iteration of mathematical exploration two major findings were discovered:

- The distance of the closest temple is highly related to the centrality of that island (how often the ships sail near the island) (see Fig. 3) and to the distance of the closest army base.
- The subset of islands shows a significant correlation between the coefficient of potential food shortages and the distance to the closest temple (see Fig. 4). This subset is made by the subtraction of islands of Rhodes and Anafi. Selection of these two islands could be investigated and argued from the historical point of view - Rhodos was a transfer point and had a specific role within trade network, Anafi had strategic importance for army.

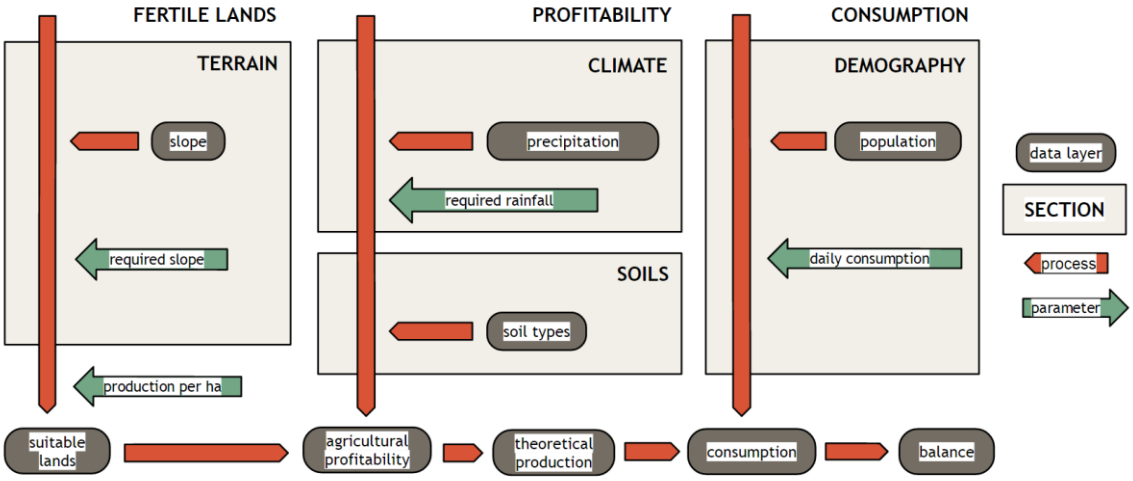

***Fig.1**: Schema of designed environmental model*

[8] https://networkx.github.io/

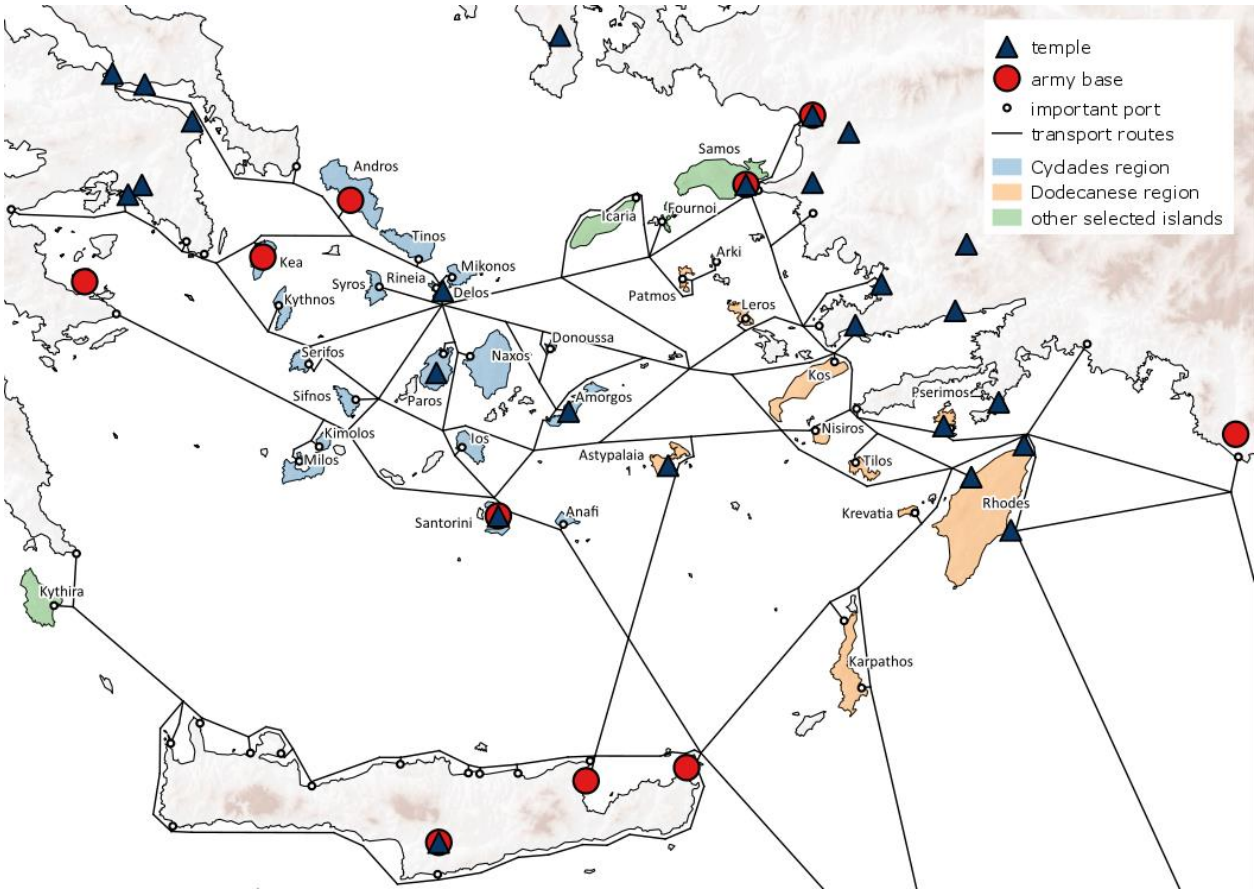

***Fig.2**: Created transportation network and the position of relevant temples and army bases for the focused area of Aegean Sea in third/second century BC*

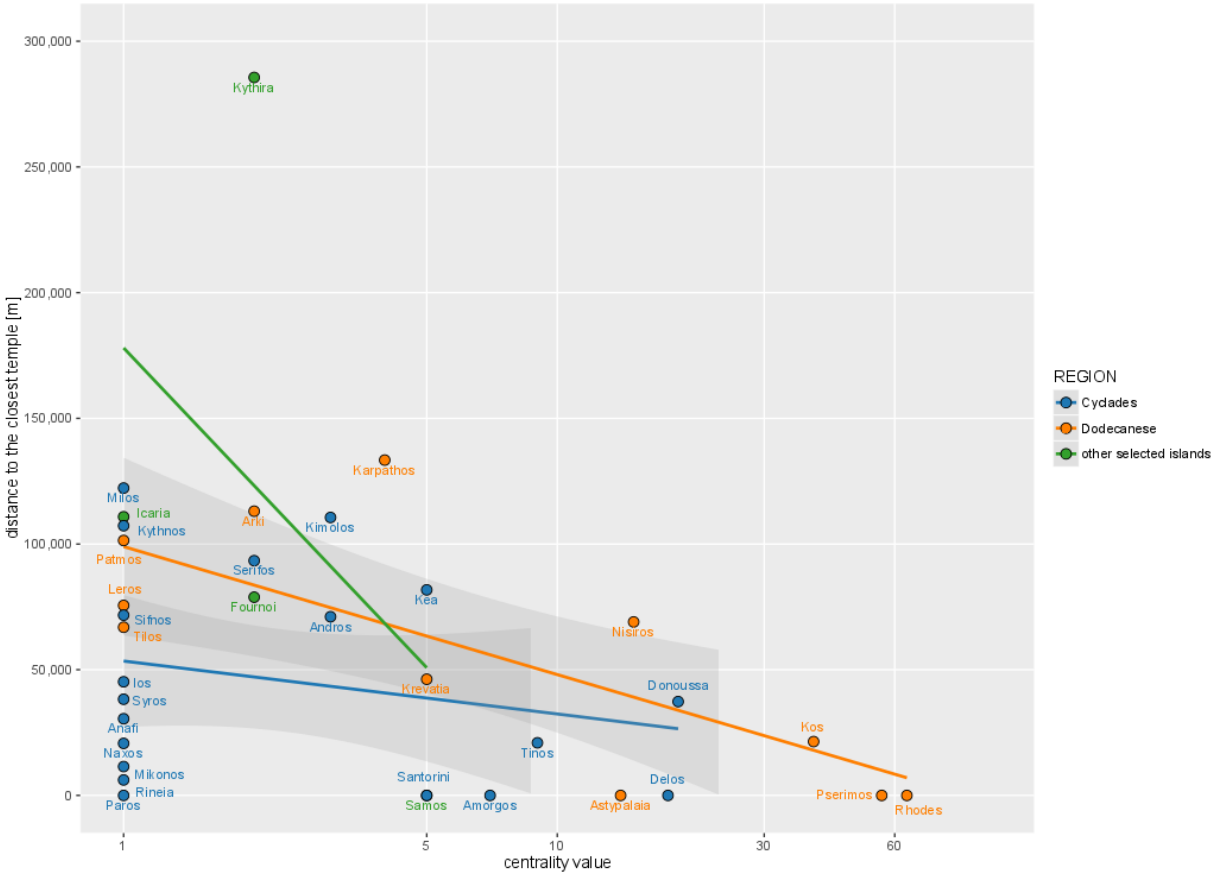

Fig. 3: *Correlation between the distance to the closest temple and centrality of island*

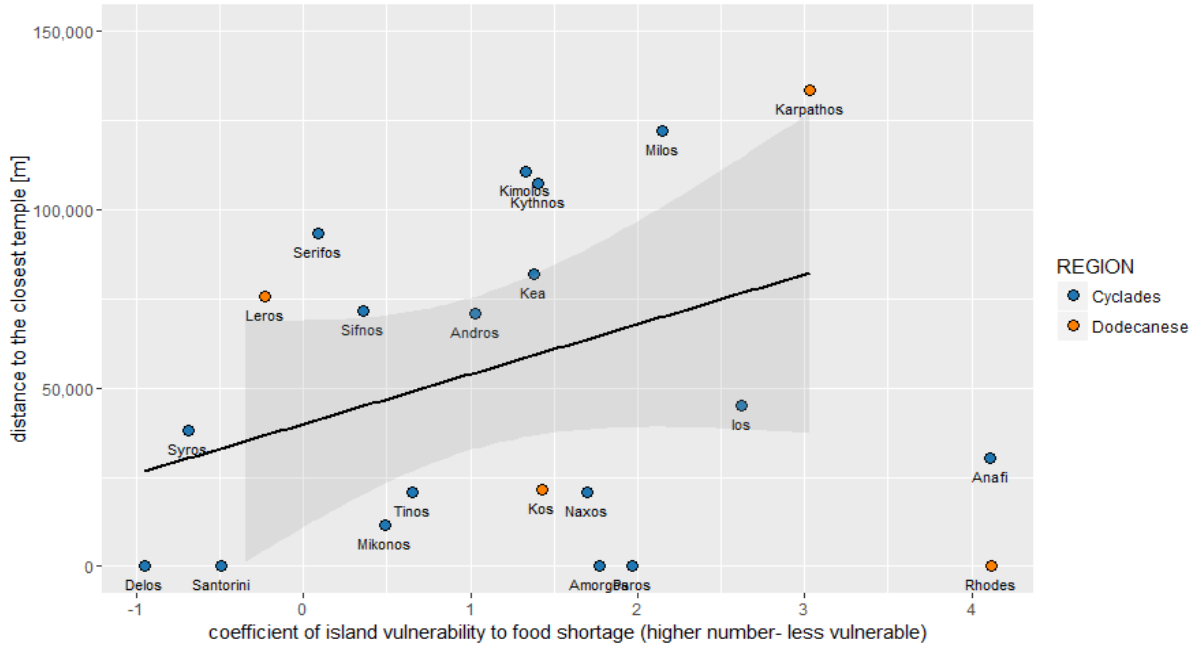

Fig. 4: *Correlation between the distance to the closest temple and vulnerability of island to food shortage (islands Anafi and Rhodes were excluded from the regression line)*

DISCUSSION

As was introduced in the first part of this paper, there are numbers of spatial historical datasets created and some of them still continually maintained. There are also several initiatives and projects that focus on the collection of relevant

historical data and their publishing to broader audience. As the quality of these data cannot be always controlled within optimal conditions, researchers should be aware of possible constraints. These constraints are dependent on the quality of various aspects of data. Used classification explained completeness, uncertainty and preciseness aspect. All of these aspects could be observed on the spatial, attributional or temporal level. These quality measures are crucial for all the following analyses. Therefore it is highly recommended to all authors of these data to provide the necessary metadata and the description of data creation process. The proper categories of precision or uncertainty could be created and stored with the data for better manipulation.

For the religious studies (as for the most of humanities) research the variety of GIS methods could be used. One of the biggest advantages of GIS and also a precondition for the interdisciplinary historical research is the possibility to work with spatiotemporal data. In the described case study, the filtering was used to subset only relevant data. In the next steps of this research the temporal aspect is intended to be added and analysed. This way a complex spatiotemporal pattern could be obtained for a modelled phenomenon.

The second crucial advantage is seen in the tools and software that comes with geographical science. This way a new data could be easily re/created with a specific architecture driven directly by the research question. In the presented case study a spatial network was created specifically for the purpose of further distance and network analyses.

Both these reasons confront the GIS as science and its future. For this purpose new methods should be implemented into GIS software that would allow cartographers to study spatiotemporal phenomenons even more deeply. Also there would be a good demand for tools possible to create, store, describe and study historical spatiotemporal data. As an example of an initiative to standardize the process of data collection and further analyses for historians is *OpenAtlas* project.

As the GIS experts are able to prepare, create and analyse required datasets, historians are the crucial part of the interdisciplinary teams to define the relevant hypothesis and interpret the results and outputs. Further expertises are required to clarify possible gaps in input datasets and the usefulness of outputs for the research agenda.

CONCLUSION AND FUTURE WORK

This paper was intended to describe selected issues of using GIS for the religious studies research. The motivation for this topic came mainly from the ongoing project of GEHIR that attempts to use the interdisciplinary approaches (mathematical/environmental models, agent-based modelling, spatiotemporal network simulations, ...) to model the spread of religions in ancient Roman Empire.

The first part of this paper lists some notable project or datasets that are relevant for this topic. As mentioned later the character of these data and uncertainty of their sources come with constraints. Within these constraints completeness, preciseness and uncertainty could be defined on the level of spatial, attributional or temporal information.

In the next part of this paper the case study in the area of Aegean Sea was introduced. This region was in the third/second century BCE influenced by the Ptolemaic dynasty and the Egyptian cults of Serapis and Isis spread there. Factors connected with this phenomenon came both from politics and trade areas. The workflow to find these correlations consisted from the environmental model, trade network redrawing and the collection of data directly connected to the cult and Egyptian army. For interpreting the plotted results and correlations some statements were made:

- The spread of studied cults was highly influenced by the centrality of particular island and the distribution of army bases in that area
- The distance from temple is in most of islands correlated with the potential of food shortage. Islands with more insufficient agriculture conditions had more often a temple in a close distance.

The presented work is only the first step. Collected values based on static network and environmental model provide the elemental insight to the reasoning of religion spatial distribution. All these data are afterwards planned to be analysed more deeply with the help of mathematical analysis. We propose to use agent based models and simulations in the study of historical relations and impact of various factors also on temporal level. There are also some plans to bring this data and information to public. The idea is to create a interactive web map, blog posts and a simulation web game.

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GEHIR

GEHIR is an interdisciplinary research project at Masaryk University, Brno, which applies innovative methods used in the study of the dynamics of complex systems (mathematical and computational modelling, network science) to the historiography of ancient Graeco-Roman religions.