GEOGRAPHIC INFORMATION SYSTEMS AND HISTORICAL RESEARCH: AN APPRAISAL

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Abstract *It is time to make a critical appraisal of the application of the Geographic Information System (GIS) to historical research. In this article I briefly review the promises and achievements of the use of this technology in history and I also consider some of its possible developments. Based on the experience of a project on the Iberian Peninsula, a special emphasis is put on transnational GIS. In the last section, the new avenues opened by GIS to historical research and the difficulties that its application also involves are considered in the light of the evolution of historiography and of the experience of using databases in history. I argue that although the application of this tool in historical research represented an important innovation, GIS did not bring about a revolution in knowledge production in history. I also raise doubts about the notion of a spatial turn in this field. I finally suggest that the emphasis should be put, not on the technology, but on the historical problems.*

Keywords: GIS, History, Transnational GIS, Spatial turn

This article intends to be a reflection on the use of the Geographic Information System (GIS) in historical research from an historian's point of view. After several years working in spatial history, where GIS has an important role to play, I became increasingly cautious regarding the promises raised by this technology since its early applications to the study of the past. I strongly believe in the contribution of GIS to historical scholarship, to change the way historians work

and disseminate their knowledge, but I suppose it is time to make a critical appraisal of the way done so far. I argue that GIS did not bring about a revolution in knowledge production in history and I also raise doubts about the notion of a spatial turn in this field. I finally suggest that the emphasis should be put, not on the technology, but on the historical problems.

I. PROMISES AND ACHIEVEMENTS

It is usually agreed that GIS was introduced in historical research in the mid-1990s.[1] The book edited by Michael Goerke is probably the first one in this field.[2] It brings together the papers presented at the workshop held at the European University Institute in 1994 when historians were still discovering the technology. The articles cover mainly the European continent but the United States and even Indonesia are also represented.

In the coming years, technology rapidly improved, became not only more powerful but also more user-friendly, and its use in historical research spread. The description of the atmosphere of the 1998 and 1999 Social Science History Association sessions on Historical GIS (HGIS) refers people's 'passionate engagement with methodology' and participants' excitement caused by the sense that they were 'making something new by using new tools'.[3] As it had happened with quantitative history, HGIS would be able to open up historical scholarship, inspire new creativity, challenge old assumptions, and promote the exploitation and understanding of new types of historical evidence.[4]

Some years later Anne Knowles, a historical geographer, although acknowledging the great progresses that had been made, also recognized that GIS's 'promise, however, is far from fully realized'.[5]

Even so, it seems that the enthusiasm of the 1990s has not vanished and a very interesting book, recently published, proposes to 'advance an even more radical conception of GIS that will reorient, and perhaps revolutionize, humanities scholarship'.[6] The sense that the application of GIS to historical research would dramatically transform knowledge production and dissemination in this field, which has accompanied HGIS development since the beginning, is still prevalent.

Progresses to date are undeniable and are reflected in both books and articles, or in many applications for the Internet.

The Association of American Geographers webpage displays a catalogue of HGIS websites.[7] The Historical GIS Research Network provides a shorter list, including some interesting European projects.[8] Overall, the references encompass nearly all continents and historical periods. Among those sites we highlight the National Historical GIS (NHGIS), one of the first areas of development. The *Great Britain Historical Geographic Information System* is recognized as the best example of these applications, considering the

amount of information available and its diversity, combining historic maps, statistical and literary sources accessible through an easy and nice to use interface.[9]

The NHGIS found its origin in the ambition to create an infrastructure able to support the mapping of different information on the territory of a country. These were costly projects in terms of creation and maintenance, which usually required a thorough research of the administrative geography of each country over time. Originally they were focused on providing demographic data.

Examples of well succeeded recent theme websites include *The Digital Atlas of Roman and Medieval Civilization* (DARMC) and *Mapping Gothic France*. In the field of urban history the *Map of Early Modern London* (MoEML) and *Locating London's Past* deserve to be mentioned. *Linguistic Geographies: the Gough map of Great Britain* is a good example of a publication of an historic map.[10]

These sites have earned their place and demonstrate the potential of publishing georeferenced historical information on the web. They represent an important area of innovation in the dissemination of scientific data. What distinguishes them from other sites is the provision of information by simultaneous reference to time and space, in this latter case through the map. They also allow the superposition of several layers of information in different formats (text, images, maps), sometimes combining past and present, by overlaying old maps and Google Maps (*Locating London's Past* and *Linguistic Geographies*) in a very realistic manner and successfully conveying a sense of place. This last feature turns some of these sites into powerful tools to engage the community, helping people to deal with sensitive issues such as race relations. In other instances, as in the case of the mass graves of the Spanish Civil War, still a highly delicate subject, we realize not only the importance of a map to analyze an historical issue but also its ability to inform people of how and where a certain process (the exhumation) is taking place and the map's crucial capacity to locate, in this case the remains of the victims, reintegrating them into the social space.[11]

Recent years witnessed the development of research in data visualization as well, with or without GIS. The *Spatial History project* at Stanford University displays very interesting results in its webpage.[12]

HGIS's contribution to the advancement of historical scholarship can not be limited, however, to these areas. Therefore, we must also look at the publication of books and articles, whose number is already considerable.[13] These works have been reviewed from time to time.[14] Overall, we can say that the initial expectations were met. In fact, the application of GIS to history helped to strengthen interdisciplinary research, creating a field of collaboration for researchers from various disciplines, from historians and geographers to computer scientists, linguists and economists to name but a few, working in the field of economic geography.

Simultaneously, this circumstance has contributed to a transformation of historical research, which in this area is increasingly a collective enterprise. Many of those working in this field will agree with the historian Richard White's view when he says: 'The scholars involved in the Spatial History Project can write books by themselves, but they cannot do a spatial history project on the scale they desire alone: we lack the knowledge, the craft, and ultimately the time'.[15]

The use of GIS has also encouraged new approaches to subjects commonly located in the historians' territory. Literature is a good example. Literary texts have always been primary sources for historical research on spaces, landscapes and places, not only because of the physical descriptions they often convey but also because of the references to how these spaces, places and landscapes have been perceived. At the same time, the text-space relation is essential to characterize an author. The ability to map textual references allows for a clearer characterization of the spatial patterns underlying the texts, concerning for example the authors' itineraries, the locations referred to or the emotions associated with those places. The GIS also facilitates the comparison of such patterns among various writers. When this analysis is done on a number of authors one can define, for example, the common literary space of a city and its evolution over time, as in the case of Lisbon studied by Daniel Alves and Ana I. Queiroz (Figure 1). When GIS analytical capabilities are combined with corpus linguistics techniques the analysis and mapping of the contents of large bodies of text becomes possible.[16]

GIS tools have also contributed to overcome longstanding barriers that have challenged historical research progress. I will give an example taken from my own research. It is known that the European population over the last century and a half has tended to concentrate on certain regions. This has also happened in Portugal, leading to a higher population density in the coastal areas on the North of the country, in contrast to the progressive depopulation of the inland regions. This trend, which has accelerated in recent decades, coupled with the ageing of population in the inland regions, became a serious concern for the whole society. Historians have long acknowledged that probably since the sixteenth century population on the northern coast presented higher density values. However, the difficulties of mapping trends of population distribution even concerning recent centuries hindered a deeper insight into this issue. Those difficulties were mainly caused by the profound reform of the administrative geography occurred in the first half of the nineteenth century and by the continuous changes in the limits of territorial units. Under these circumstances, the creation of spatial data series comparable over time was a very difficult undertaking. Much of the work behind the NHGIS had to do initially with the solution of these kinds of problems.

For the first time, the drawing up of detailed maps of the Portuguese territory allowed us to quantify and represent the contrasts of population density since 1801. It was thus possible to demonstrate that the concentration of the
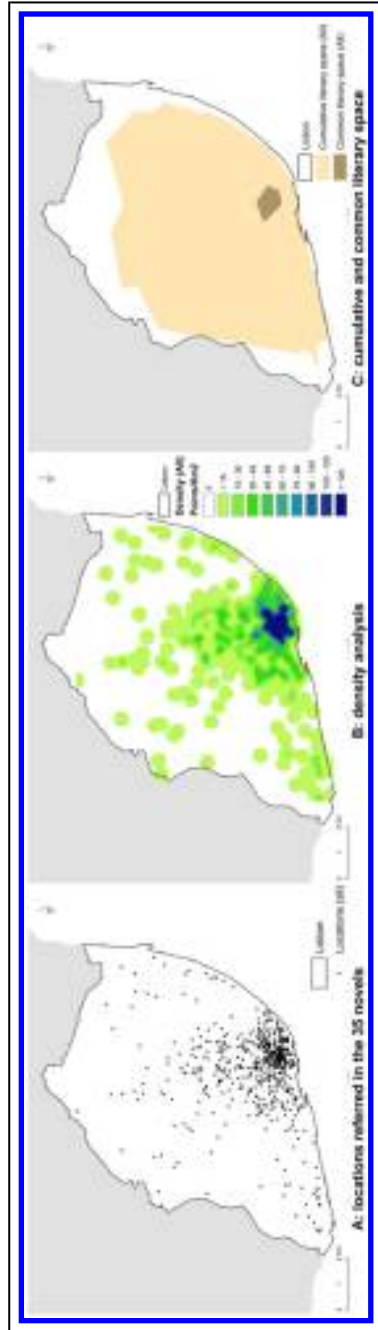
Figure 1. Lisbon's literary space, 1852–2009.

Portuguese population in the northern coastal zone is a structural phenomenon. At the same time, controlled application of data interpolation techniques allowed us to produce a series of maps depicting the distribution of population density over the last two hundred years, using the administrative division of 2001, thus eliminating the effect of the changing geography (Figure 2).[17]

Finally, GIS enabled researchers to question established descriptions or explanations. The study of infant mortality decline in England and Wales between 1851 and 1911 by Ian Gregory, an historical geographer, is an interesting example. Applying several spatial analysis methods to a source that had already been studied by other researchers, Gregory showed that 'patterns of infant mortality decline in different parts of the country were more complex than has previously been described.' He was also able to argue that 'the largest declines and earliest declines in infant mortality were found in rural parts of the southeast of England'. The change was therefore not driven by urban areas, as it had been put forward previously.[18]

Before discussing the significance of these accomplishments, let us consider some possible developments in the application of GIS to historical research.

2. DEVELOPMENTS

There is a certain consensus around some of the future directions concerning the application of GIS to history. We need to address the specific problems that the uncertainty of some historical data poses to GIS; developments regarding the analysis of textual information are also required, considering the importance of this type of data in history; the interest to explore new forms of visualization, combining the spatial and the temporal dimensions is a promising field; and there is also a need to develop the conceptual framework to deal with the notion of space in history in order to better understand the relations between space, individuals and societies across time.

Beyond these issues and as a natural development of the work done at national level, global and transnational GIS projects are also attracting an increasing attention. I will exemplify not only the possibilities opened up by the enlargement of the spatial field of analysis, but also the problems raised by this approach. For this purpose, I will refer to an ongoing project on the Iberian Peninsula.

The globalization process and subsequent increased world interconnectedness led to the emergence of new historical problems and new research perspectives for which the nation-state is no longer an adequate framework. Political unification in Europe had the same effect. It is therefore not surprising that in the last decades global history and transnational history have raised a growing interest.[19] This concern has also been shared by HGIS researchers. The historian Jack B. Owens presented his vision of a GIS able to support 'a geographically-
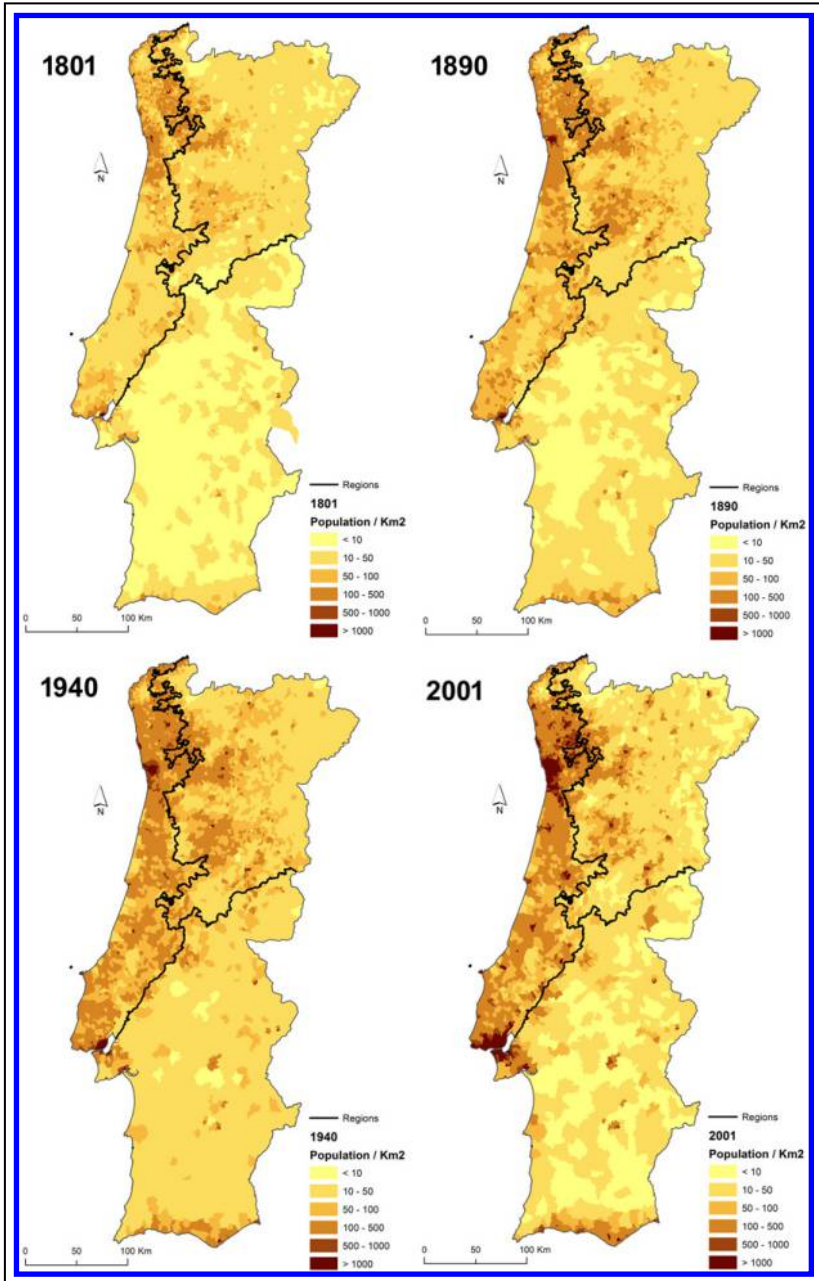
Figure 2. Evolution of population density in Portugal 1801–2001.

integrated, connected world history'.[20] A recent paper submitted to the United States National Science Foundation put forward the need for a global HGIS, stating that 'grand challenges facing society require long-term global perspectives'.[21] At European level, the creation of an HGISNet-Europe was recently advocated.[22]

In order to address problems such as the uncertainty regarding the boundaries of a given unit or the location of a place, the imprecision that affects date references and the multiple historical place names variants, the aforementioned papers suggest building either a gazetteer – a list of place names and their attributes – or a more sophisticated ontology, which beyond the latter features also includes the relations between the different geographical entities.[23] The same papers also stress the need for data and metadata standards to facilitate information interchange.

In spite of being aware of the possibilities created by the global or transnational HGIS there are not many examples of such systems. *Geopolis* aims at studying world urbanization and the dynamics of world population distribution from 1800 onwards; *AfricaMap* collects contemporary and historic maps and data on this continent.[24] The geographer Jordi Martí-Henneberg has been working for some time on *The Socio-Economic Atlas of Europe (1850–2000)*. The project began with the design of digital cartography covering the administrative units of the whole Western and Central Europe. So far, the base maps produced substantiate the difficulty of the task, which stems from the different size of the European states, their diverse internal organization and the instability of their internal and external boundaries. The ultimate purpose of the project is to study territorial disequilibria within Europe as a whole and also within each individual state. Regarding population concentration, Jordi Martí-Henneberg corroborates the idea that 'Europe's regional inequalities have been exacerbated' between 1870 and 2000. He also argues that the analysis of population distribution patterns over the same period of time shows "stability in both underpopulated and very densely populated areas.' This happens 'despite enormous changes in the factors that have determined the location of population and economic activities since 1870.'[25]

It is important to have this broad European perspective but the map that supports its formulation, although requiring an enormous amount of work, only represents large territorial units. This scale of observation imposes limits to the possibility of performing some interesting spatial analyzes, particularly those combining population and physical geography. Therefore, if we want to get a more precise description of population distribution patterns and deepen their explanation we have to narrow down the geographic scope of the study.

Using a map of extensive administrative divisions, a Spanish historical demographer showed that at least by the end of the eighteenth century population in Spain tended to be concentrated in the coastal areas.[26] The very accurate

maps displaying population distribution in this country along the twentieth century plainly confirmed the persistence of this long term trend.[27] As we have already mentioned, a similar pattern applies to Portugal. Bearing in mind that the two countries share the same geographical area, the benefits of addressing this historical issue from a transnational perspective seem obvious.

In fact, the Iberian Peninsula is a field of analysis of particular interest. It is a well delineated geographic entity, characterized by marked natural contrasts, defining regions that span beyond national borders. The border between the two countries is actually a political construct whose origins lie in the Roman Empire. It was formally established at the end of the thirteenth century (1297) and only suffered minor changes in 1801.

The intersection between geographic and political factors creates a challenging setting for research and stimulates the rise of new questions and approaches. What are the patterns of population distribution in the entire Peninsula? How did such an enduring border influence those patterns? Is there a significant difference in population distribution in cross-border regions? What are the factors that explain population distribution? What was the role of geographic factors? The main hypotheses underlying this ongoing project are the following: a) patterns that were separately identified in Portugal and in Spain are part of an historical process taking place in the vast peninsular territory regardless of national states; b) geographic factors had a decisive importance in population location even after the Second World War, an era of rapid economic growth and modernization.

To test these hypotheses for the period 1877–2001, we undertook the construction of what may turn out to be the Iberian Peninsula HGIS. Inasmuch as we are dealing with quantitative information, with a precise geographic reference, the above-mentioned uncertainty problems are of marginal importance.

To proceed, we had to deal with two problems: the choice of the administrative units and data interpolation. The analysis of the spatial distribution of a quantitative variable across the territory of two countries requires the adoption of administrative units of similar size. The difficulty lies in the fact that for the same administrative level, the divisions in Portugal and in Spain were not, in the past, and are not currently equivalent in their extent. From the largest to the smallest in size, and from the highest to the lowest in terms of political and administrative levels, there are districts, municipalities and parishes in Portugal, and autonomous communities, provinces and municipalities in Spain. The analysis of the average areas of these administrative divisions led us to the conclusion that only the combination of Portuguese districts with Spanish provinces and of Portuguese parishes with Spanish municipalities was acceptable, even if they do not take up the same position in the respective hierarchy (Figure 3).

Figure 3. Portugal's and Spain's administrative divisions.

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Eventually we opted for the latter combination because these administrative units are the smallest in both countries, allowing not only in-depth analyses but also the reconstitution of higher territorial divisions. Although it seems the best, this choice does not eliminate differences in size between Portuguese parishes and Spanish municipalities, and their disparity across the Peninsula from North to South, which can clearly be seen on the map. These differences affect the maps representing population densities and introduce some bias in quantitative analysis.

To overcome the problems caused by changes in territorial units, data on resident population from both countries were interpolated onto a 2001 map. In the Spanish case this was done 'manually', without any GIS, and the reconstitution of the historical population of a 2001 municipality was based on information regarding population settlements included in its territory in the latter year provided by the previous censuses. As far as Portugal is concerned, two geographic data interpolation methods already tested in an earlier work were used.[28]

We divided the time span under consideration in two periods: 1877–1940 and 1940–2001. The turning point corresponds to the beginning of the Second World War which separates an era of slow economic growth and slow modernization from the post-war decades of rapid change in economy and society.

Figure 4 shows population density in 1940, at the end of the first period. Population is concentrated in the coastal regions; in the center of the Peninsula Madrid stands out and the growth of some urban areas in the peninsular inland is also noticeable. In this map it is visually impossible to distinguish Portugal from Spain. The concentration of population in the Atlantic coast north of the river Tagus in the Portuguese territory continues to Galicia in Spain and forms the largest continuous high density area in the Peninsula.

To confirm the distribution patterns we calculated the Local Moran Indicator for the years 1877, 1940 and 2001.[29] The corresponding maps identify a persistent large zone of low population density clusters, extending from the Pyrenees to the South of Portugal. With the exception of some areas, where it stretches to the sea, this zone expands throughout the inland region, whose densities contrast with coastal ones. The vigorous emergence of high density clusters in the second half of the twentieth century is a remarkable change, clearly visible in Figure 5. These patterns of population distribution seem to be independent of the existence of national borders. The closer observation of cross-border regions confirms this idea.

Henceforth, the real challenge will be to explain what we observed. We are currently testing the influence of climate, terrain elevation, slope, distance to rivers and to the coast in the locational patterns and hope to be able to present our conclusions soon.[30]
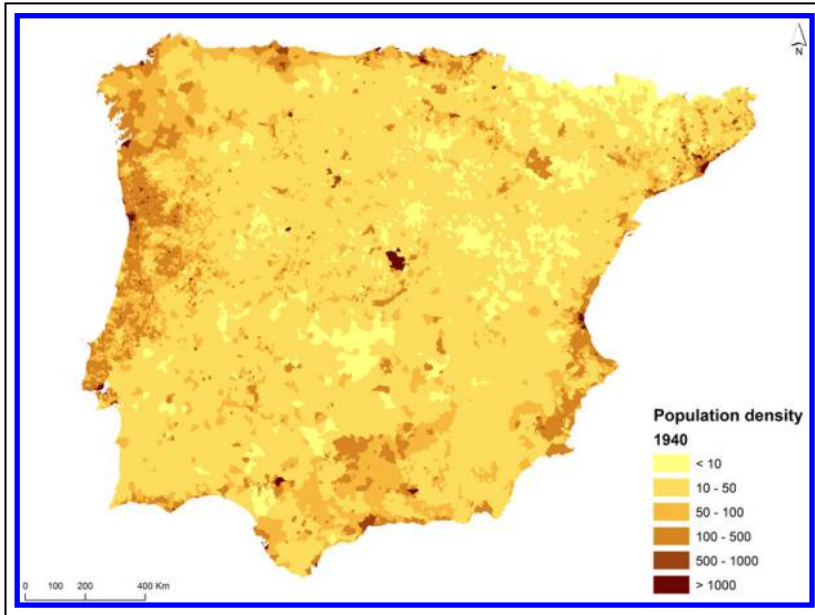
Figure 4. Population density in the Iberian Peninsula in 1940.

In a project like this, GIS proves to be an invaluable tool, providing powerful analytical capabilities that were not within the reach of historians before. This application represents therefore an unquestionable progress. However, the development of an Iberian Peninsula HGIS, though restricted to the last two centuries, faces important obstacles involving maps and data sets comparability.

Considering the size of the Spanish territory, we understand the difficulty of producing a digital map collection at municipal level for at least population censuses years, as we did in Portugal concerning the parishes. However, given the need for interpolating data, without those maps the analysis of other variables on Spanish history will not be possible, at least with this level of detail, which may be crucial to address some research questions.

Anyhow, before setting out such a mapping project, a careful consideration of its costs and benefits is needed. Does the available information justify, in quality and in quantity such a costly undertaking? From a transnational perspective the answer is not clear-cut. In fact, in both countries historical information at the aforementioned level (parishes/municipalities) is limited, mainly concerning population. In Portugal, other important data, such as infant mortality, occupational structure or conscription were usually collected in municipalities. The difference in size of the latter in both countries and the
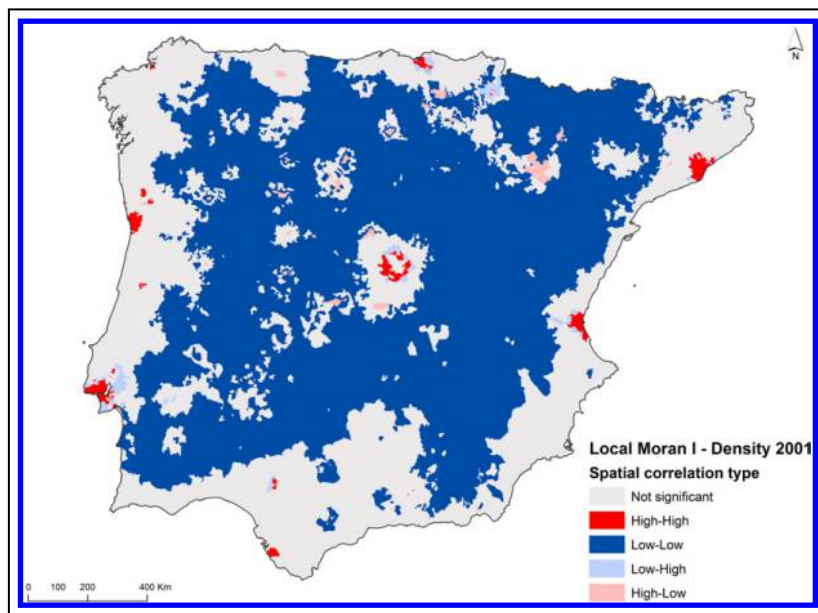
Figure 5. Local Moran Indicator – population density in the Iberian Peninsula in 2001.

inexistence in Spain of a territorial division equivalent in extent to Portuguese municipalities, constitute a serious impediment to transnational studies in the Iberian space.

This kind of problem affects the development of transnational HGIS in other parts of Europe as well, but usually in most European areas we must add an additional difficulty due to external boundary instability. Actually a study focused on the cities or on other places would not encounter the same problems.

In the end, the solution lies in the design of research questions, in the balance between the resources available and those missing, in the strategies to address research problems and in the combination of different spatial ranges and different scales of analysis.

GIS opened new avenues to historical research but its application also involves some difficulties. In the next section I will try to put both into perspective.

3. DISCUSSION AND CONCLUSION

After all that has been said, is it still possible to argue that GIS brought about a revolution in the work of historians? For an historian from mainland Europe, educated in the 1970s under the influence of the *Annales*, GIS introduction in

historical research represented a natural continuation and a means to deepen what historians like Fernand Braudel and others, gathered around that journal, had been defending for a long time: the cooperation between history and other subjects from the field of humanities and social sciences, with an emphasis on geography, which should be a fruitful interaction for all parties and stimulate the circulation of concepts and methods; the search for new subjects and the exploration of new sources; the combination of qualitative and quantitative methods; and attention to space, viewed as an essential dimension of the historical development.[31] The very use of computers was early on advocated by the historians of the *Annales.*[32]

One of the major contributions of GIS to historical research was the stimulus to sustain and renew the awareness of the importance of space in social relationships, following a similar trend in other social sciences. However, this movement, which has broader intellectual roots, cannot be qualified as a turn, at least in history, but rather as the deepening of an approach to questions that have never ceased to be on the research agenda in history, which can now be addressed with new tools and taking advantage of new theoretical reflections.[33]

Why, then, the excitement, the sense of revolution created by the application of GIS from the beginning? This sense was probably caused by the ease in producing theme maps, by the ability to relate alphanumeric data and the points, lines and polygons representing geographic features and by the possibilities opened up by the combination of multiple layers of information. Additionally, that sense was also prompted by the spatial analysis capabilities that were from now on within reach of the historian. The latter consideration is, in my opinion the most decisive, the one that allows us to go further in historical research. However, its implementation is dependent on the one hand on the capacity to produce base maps at different scales, in some cases highly detailed, and on the other hand on the existence of reliable quantitative data. The ability to process qualitative information is also crucial in this area and interesting progresses have been made, as noted earlier concerning literary studies. Nevertheless in this regard we need to continue efforts to create new analytical methods.

In any case, GIS was originally designed to deal with accurate spatial information and precise numerical data. In this respect it shows an enormous potential that has only begun to be explored in the field of history. The more we go back in time, however, the more difficult it becomes to meet the above mentioned requirements regarding base maps and quantitative data, given the absence, the vagueness and the uncertainty of some historical information.[34] The ease for drawing theme maps entails the production of base maps, which is not a simple task, even nowadays. The problems raised by the reconstitution of the evolution of a country's administrative divisions in the last two centuries were clearly evident in the NHGIS experiences. Even after this reconstruction, the comparison of numerical data over time is not straightforward and requires

command of data interpolation techniques. If on the one hand the adoption of a transnational scale of analysis, even regarding recent times, opens stimulating prospects, on the other hand it raises problems of maps and data comparability, as we saw above.

These problems have occupied much of the researchers' attention in this area and represent both challenges and limitations to the application of GIS to history. Difficulties of the same type, arising from the fragmentary, vague and unstructured nature of some of the historical information had already been felt regarding the application of databases, usually based on rigorous and inflexible logic models.

Moreover, the use of GIS in historical research seems more intense in the Anglo-Saxon world: the Florence workshop of 1994 shows that although the interest in continental Europe emerged early, the movement did not have the same vitality here as in the United States or in the United Kingdom. A glance at the literature referenced on the Historical GIS Research Network website evidences the small number of works written in a language other than English and the scarce presence of historians from mainland Europe. The sessions of the Spatial and Digital History Network, at the European Social Science History Conference, held in Glasgow in April 2012, point in the same direction: the presence of German, French, Italian or Spanish historians, just to mention some of the most important European historiographies, among the speakers being clearly limited.[35]

Finally, we must remember that although the number of GIS users is growing and the interest in its use is spreading, GIS is still not able to captivate mainstream historians. As was the case decades ago with databases, this is largely due to the technical knowledge that its application requires. To overcome this situation and turn GIS into a tool commonly used by historians we need to continue providing training to researchers who express their interest, to enable them to at least engage in a dialogue with GIS experts. At the same time, we must prepare historians to work in multidisciplinary teams, where, among others, these experts should be present. But above all, we have to continue to demonstrate, through results, the potential of this tool.

To conclude, in the historiographies under a stronger influence of the *Annales*, where the concern with the spatial dimension of historical facts was at the heart of the subject, GIS did not cause any revolution in historical scholarship. Anyway, the application of this tool to research in this field was an important innovation which has revealed its potential in the last decades. Its development in some areas, however, faces important challenges.

For those who believe that the use of GIS enriches the historian's analytical capabilities and are persuaded of the need of pursuing a research program focused both on time and space, and who would like to see this perspective increasingly disseminated amongst historians, it seems that after all these years

the emphasis should be put not on HGIS, an area characterized by the application of a technology, but on spatial history, a field where space receives a special attention. The focus should therefore be put on the historical problems and not on the tool, whose fascination may easily divert the historian from his essential purpose, the production of historical knowledge.

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