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5. GIS IN THE STUDIES OF ŁÓDŹ GEOGRAPHERS

5.1. Introduction

In 2010, it has been 20 years since the term "geographic information science" was first used, and the US National Center for Geographic Information and Analysis funded by the National Science Foundation was established. This period was summed up by M. Goodchild (2010) in an article entitled *Twenty years of progress: GIScience in 2010*. In the study, he recalls the beginning of GIS, the scientific and institutional achievements over the 20 years, as well as perspectives for further development and the deliberations of the 4th International Symposium on Spatial Data Handling in 1990, where he formulated the term GIScience for the first time.

The discussion on the role of Geographic Information Systems (GIS) in science had lasted for many years all over the world and its conclusions can be found in a 1997 article entitled *GIS: tool or science?*[1] by Dawn J. Wright, Michael F. Goodchild and James D. Proctor. Much of it is devoted to the debate over GIS-L, which took place

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[1] The article is available online at http:///dusk.geo.orst.edu/annals.html

in 1993 via e-mail on a special server, where the users could voice their opinions. Their positions were different, but focused on three issues (Wright et al. 1997):

1. GIS as a tool which is used during research.
2. The development of tools – mainly information technology – used in GIS.
3. GIS as a science.

The first issue is present when GIS is used at some stage of a scientific study which requires spatial data, their analysis using specific software or hardware. GIS can be one of many tools used in the solution of scientific problems and its main aim is to accelerate it. This is not a universal tool such as a calculator or a text editor that can be used for many purposes. GIS is a tool that can be used in any discipline investigating different phenomena occurring on Earth, so it is especially useful in geography (Wright et al. 1997). Participants in the discussion claimed that a software application cannot be described as science, but as a tool or technique, so it is part of engineering, not science. The only exception in which they saw GIS as a science was its use in the discipline of geography (Wright et al. 1997).

In the question of whether GIS is a tool or a science, another intermediate stance appeared in the GIS-L discussion, as the computer science development of GIS tools was pointed out. The authors are specialists in various disciplines, including computer science, engineering, mathematics, and geography. The panellists pointed to the unique ability of geographers, such as excellent understanding of geographical concepts, methods of spatial analysis and the ability to integrate and understand the many processes that affect the various phenomena on the Earth's surface that are useful in the creation of the GIS software (Wright et al. 1997).

The most controversial question concerned GIS a science more closely related with computer science or geography. At the beginning of this part of the discussion, some participants of the GIS-L posed such questions as "What is science?", "Are there hypotheses and theories that can be formulated and tested using GIS?" The participants showed, that the relationship between GIS and geog-

raphy is the strongest, and GIS is just a sub-discipline of computer sciences. As pointed out by D. Bartlett, many pioneers of GIS were geographers (e.g. Coppock, Rhinda Bickmore and Unwin in the UK, Tomilson, Garrison, Berry, Tobler, Marble in the US), and they, more than specialists in different fields, can identify and understand spatial relations and computer technologies (Wright et al. 1997). The debate arising from the ambiguity of GIS as a science also stems from the context of wider trends in science and society. GIS is part of both the traditional science that includes mathematical assumptions, testing hypotheses, generalisations, and a more general attitude of knowledge seeking (Wright et al. 1997).

5.2. GIS in Polish geography

In Poland, the development of Geographic Information Systems started at the onset of the 1990s. This was due to two reasons, political and civilisation. The "iron curtain" between Polish science and technical and, partially, scientific novelties hindered the flow of scientific information, and the technical solutions were designed to use the potential of Poland and Comecon countries. In the first half of the 1980s, when ESRI, Intergraph and MapInfo started marketing their first products in the US, Poland was still widely using ODRA computers with punch-card readers. It was only in the late 1980s and early 1990s that the development of hardware and software – the emergence of the first PCs – allowed a small group of Polish researchers to use them. Above all, they were seen as having geographic and computer interests, and thus created maps differently from their contemporary cartographers. They worked in various academic centres and searched for their own scientific routes using GIS, while promoting it in their educational activities. In 1990, surveyor J. Gaździcki published a manual entitled *Spatial information systems*. In the following years, geographers published more academic textbooks for both students and academics in geography concerning this new field (Werner 1992, Kistowski 1993, Kozak

1997, Urbański 1997, Widacki 1997, Magnuszewski 1999[2]). Given the civilisation delay in Poland after 1989 at the beginning of the political transition, we should recognise the first teaching materials and concurrent scientific research using GIS in Poland (Jażdżewska and Urbański 2013).

The first scientific works in the 1990s were devoted to familiarise the academic community in Poland with GIS and its possible uses (e.g. Kistowski 1993, Werner 1992, Paszczyk et al. 1994, Fiejdasz and Widacki 1995, Hencz (now Jażdżewska) 1995, Urbański 1997), while further works used the Geographic Information Systems in research (Werner and Prokop 1999). Their review, entitled Geographic *Information Systems – unwated child or hope for Polish geography? (Geography and GIS in Poland in the years 1990–1999)* was done by M. Kistowski (2001).

At the turn of the 20th and 21st centuries, more and more geographic works using Geographic Information Systems were published, but not all authors put GIS in their titles, choosing to use keywords instead. The fact that the acronym GIS is not put in the title may mean that it was treated as a tool used in the research procedure. Including it in the title means a comprehensive solution to the research problem using GIS. Why do the first Polish publications lack the GIS acronym? Scientific papers, especially degree papers, require a review from competent and independent scientists in a given field. Until recently, Poland lacked reviewers who represented a scientific approach to GIS, so young researchers could not count on competent reviewers with professorial degrees (Jażdżewska and Urbański 2013).

The discussion about the role of GIS in science still continues in Polish universities, with talks at scientific meetings of sub-disciplines of geography and when attempting to start new faculties such as geoinformation in Polish universities. Participants of the 6th Forum of Geographers in 2010 in Cracow and of the 7th Forum of Geographers in 2011 in Poznań exchanged remarks concerning the

[2] At the same time as the geographers' works, there were also publications from geodetic surveyors.

role of GIS in teaching and presented the results of their research. (Jażdżewska and Urbański 2013).

Polish geographers have the same three approaches to the problem as the participants of the GIS-L debate (Wright et al. 1997).[3]

First, they see GIS as a tool. At some stage of their studies, many Polish geographers use spatial data such as orthophotographic maps, vector maps and other that usually require them to manage and analyse using GIS software. In this case, GIS is a tool more sophisticated than a calculator, which is mainly meant to process the collected data and speed up the research. In this approach, Polish researchers and their foreign colleagues use known quantitative methods developed in the form of tools (functions of GIS software), or contract IT professionals to design new algorithms and programmes. In this approach to GIS as a tool, it is rare to see the researcher develop GIS software on their own. Typically, research teams are formed that include programmers and computer scientists, or the development is contracted to a third party. As mentioned earlier, the collaboration between geographers and computer engineers leads to second perspective on the role of GIS in science, namely the development of software that is part of the GIS. This is an extremely important role, in which geographers inspire the development of the Geographic Information System, but projects are created by software engineers. The appearance of people who have training and experience in both areas, the formation of new fields of study such as geoinformatics, geomatics and geoinformation cause an acceleration in the development of GIS software. However, we should acknowledge that the development of commercial solutions in this area is faster than the development of scientific studies proposing new computer applications (Jażdżewska and Urbański 2013).

Thirdly, GIS as a science. I. Jażdżewska and J. Urbański (2013) are convinced that a scientist can consider GIS a universal workshop to pose and test hypotheses related to spatial information. This applies to a situation where the Geographical Information System is

[3] A nation-wide discussion on the issue would be beneficial.

used to comprehensively solve a scientific problem. Starting with posing a research hypothesis, through collecting source data, their development, spatial analyses, verification of the hypothesis to the conclusion, the research process takes place within a Geographical Information System. It can be assumed that the GIS method (Figure 5.1) should take into account all of the above steps, while other research methods (such as historical analysis, social research, chemical research etc.) can be a follow up, and not the leading method.

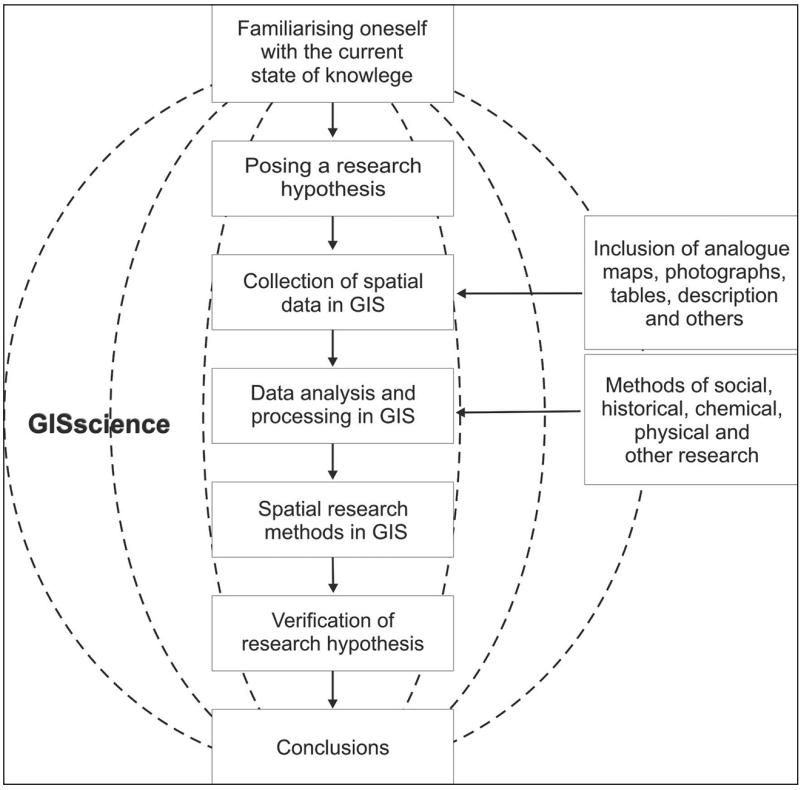

Figure 5.1. Conceptualisation of GIS as a science

Source: I. Jażdżewska and J. Urbański (2013)

5.3. GIS in the studies of Łódź geographers

The scientific community of geographers in the University of Łódź uses GIS for scientific research to a different extent, mainly as a tool for spatial analyses of the subject of their studies. They include both socio-economic geographers and physical geographers. The first work on a doctoral degree, which can be considered as representative for GIS science was the doctoral thesis of Iwona Jażdżewska in 1998 entitled *Functional and morphological transformations in Rzgow village in the light of numerical methods* under the direction of Professor Stanisław Liszewski, fragments of which were published in 1999 (Jażdżewska 1999b). Another was the dissertation by Anna Majchrowska in 2001 entitled *The impact of anthropogenic environmental changes on the western part of the Lodz province (with the use of Geographical Information Systems)*, promoter Tadeusz Krzemiński (Majchrowska 2002). Ten years later, in 2012 Alexander Szmidt submitted his thesis *The effect of substrate on the surface and Quaternary sediments in the Łódź province in the light of chosen GIS methods* under the direction of Professor Zbigniew Rdzany. One example of a post-doctoral degree dissertation was the 2008 paper *The transformation of urban settlement network in Poland in the light of mathematical methods* (Jażdżewska 2008). More and more young students of geographical sciences in Łódź treat GIS as a universal workshop for posing and verifying hypotheses related to spatial data. They publish their first works in scientific journals and seem to be trained in geoinformation.

In order to learn the opinion of researchers in the Łódź centre concerning the role of GIS in their professional careers, a survey was sent to them.[4] Only 20 people answered (15% of employees). They included professors (15%), associate professors (15%), doctors (60%) and masters (10%). The results have shown, that the first

[4] The survey was sent via the Internet, because it is assumed that the supporters of GIS are proficient in using a computer.

ones to join the GIS community were the social and economic geographers, followed a couple of years later by physical geographers. They were the people employed in the period of 1970–1999, when GIS was entering Polish science. All subjects were self-taught, some of them had the opportunity to get acquainted with the possibilities of using GIS analysis on internships abroad (in such places as Utrecht, Paris, Bari, Marseille). They originally performed independent simple analyses using GIS, now some of them have them made by third parties. They worked with basic software packages (MapInfo, IDRISI, CADGIS, Arc Info, Atlas GIS, QGIS, Surfer, Map marker), and later began using specialised plugins dedicated to such fields as hydrology, climatology. Some of these people wrote software for their own scientific purposes (Fortran, Gras, Matlab).

An analysis of the questionnaires shows that the widespread interest in GIS was started by the young generation of scientists employed in the 21st century, as 85% of the 70% of respondents who started using GIS in their research in 2000 were young scientists. Many of them had the opportunity to learn GIS in college courses, trainings, received assistance from their colleagues. Some of them were also self-taught. They are using ARCGIS, MapInfo, IDRISI, CADGIS, GRASS, QGIS, Workstation, advanced GIS software packages dedicated to their discipline. The group includes some people developing their own software (Fortran, Pascal, Matlab), as well as beginner Python programmers.

At the moment, there are slightly more (50%) social and economic geographers than physical geographers (40%) among researchers using GIS, with 10% responding that they represent the field of geoinformation. When asked "Are you going to develop your skills in the use of GIS?", 85% of respondents answered "yes, of course", 10% "yes but only in order not to forget what I have learned", with one person declaring that they will no longer learn GIS, as they commission their works to third parties.

What are the scientific problems discussed by the "fans" of GIS in Łódź? An analysis of their publications indicates that they are mainly working in the field of socio-economic geography, including:

1. Settlement:

• functional and morphological transformations in the suburban area of large cities (Jażdżewska 1999b, c), brownfields and green areas in the city (Sobczyński and Wosiak 2002), land cover in the surrounding of motorways (Lechowski 2013);

• functional and spatial transformation in developed areas (Jażdżewska 1999a, b);

• morphological analysis of plots of land (ownership, size, shape, degree of coverage) and their distribution (Jażdżewska 1999a);

• disparities in urbanisation (Jażdżewska 2005);

• transformations of urban settlement network in Poland in the regional scale of one province (Jażdżewska 2001b), region (Jażdżewska 2012a) as in the whole Poland (Jażdżewska 2008, 2012b);

• analysis of sacred space and landscape of the city, (Jażdżewska 2001a, 2007a, 2010a, c, Dmochowska-Dudek and Klima 2012, Mordwa 2012, Sobczyński 2012);

2. Social geography:

• differentiation of voting behaviour (Sobczyński 2000, Frykowski and Jażdżewska 2006, Dzieciuchowicz and Dmochowska-Dudek 2012). Diversity of socio-economic characteristics in an agglomeration (Jażdżewska 2002);

• role of mass media in Poland in process of the system's transformation (Jażdżewska and Rykiel 2002);

• civil activity in the context of economic development (Jażdżewska and Frykowski 2009);

• spatial conflicts – the NIMBY syndrome (Dmochowska-Dudek 2013);

• crime in the urban area (Mordwa 2011a, b, 2012, 2013a, b);

• purchasing and spatial behaviour of customers in shopping centres (Rochmińska 2013);

3. Physical geography:

• applications of GIS in hydrology (Bartnik and Jokiel 1999, 2002);

• glacial processes in the development of sculpture of the southern margin of the Koło basin (Rdzany et al. 2013);

• the assessment of the usefulness of automatic determination of skeletal lines for geomorphological analyses (Jaskulski and Szmidt 2013b);

• a visualisation of 40-year-old concepts of professor Klatkowa using GIS methods (Jaskulski and Szmidt 2012);

4. Interdisciplinary, which concerned:

• extraordinary incidents in the road transport infrastructure of Łódź province, with effects related to the environment of river valleys, including river waters (Ziułkiewicz 2007);

• determining the changes in the amount of potential flood losses based on an analysis of the spatial distribution of forms of floodplains development (Głosińska and Lechowski 2013).

Spatial analyses were and are the domain of geography and Geographic Information Systems expanded the possibilities of spatial analysis. We can see that Łódź geographers use the following methods of spatial analysis based on GIS from among the many cartographic methods (such as cartograms, cartodiargams etc.):

• the study of changes in land-use structure using K. Doi method which is a modification of the method of J.C. Weaver (Jażdżewska 1999a, b);

• the use of buffer zones around high speed roads and motorways to study changes within them (Jażdżewska 1999a, b, Lechowski 2013);

• the use of centroids to analyse the distribution of plots in the suburban area (Jażdżewska 1999a, b) and to analyse the changes the centres of gravity of cities and urban population in Poland (Jażdżewska 2006a);

• the use of k-means to study urban settlement network. The relationship between the administrative division and the urban settlement network in Poland. The structure and spatial typology of crime in Poland (Jażdżewska 2006b, Mordwa 2012);

• the use of taxonomic methods for regionalisation (Jażdżewska 2008, 2010c);

• a presentation of the rank-size Zipf rule in terms of time-space (Jażdżewska 2007b, 2008);

• using non-parametric kernel functions method for the presentation of changes in population density (Jażdżewska 2012a), changes in land use around the motorway (Lechowski 2013);

• the use of hexagonal reference fields area of 0.5 ha for the analysis of potential changes in flood losses (Głosińska and Lechowski 2013);

• the creation of a geodatabase for the GIS analyses (Nalej 2013, Jaskulski and Szmidt 2013a).

Another aspect of the use of scientific experience of the geographers of Łódź working in GIS were the pages in the Atlas of Łódź (2002, annexes in 2009, 2012), edited by S. Liszewski, in which a number of authors from the Faculty of Geographical Sciences used the geodetic data and their own data for the presentation of spatial structures of the city, including: *The multinational cultural heritage of Łódź* (Kulesza 2012), *The territorial divisions of Łódź* (Jażdżewska and Lechowski 2012), *The road and street network in Łódź* (Jażdżewska and Godula 2012), *Voting behaviours of the inhabitants of Łódź: local elections in 2010* (Dzieciuchowicz and Dmochowska-Dudek 2012).

At the Faculty of Geographical Sciences, University of Łódź, a team of employees of the Department of Geoinformation team joined the discipline of *GISience.* They initiated (together with prof. Jacek Urbański of University of Gdańsk) Poland's first conference entitled "GIS in science", whose first edition took place in 2012, and the subsequent ones will be held at universities all over Poland.[5] It may become the nucleus for a broader discussion about the role of GIS science in the research by Polish geographers, as well as of the development of the discipline in Poland. The activities in teaching and science has led to the creation of a "Piksel" students' group, which allows the students to develop their interest in GIS. Participation in scientific conferences, work in research teams, collaboration with practicioners, classes in geography and geoinformation should

[5] The 2nd GIS in science conference was organised in Lublin, at the Maria Skłodowska-Curie University, while the third one will take place at the University of Gdańsk.

result in some interesting experiences for the Geoinformation Department team.

The use of Geographical Information Systems among the teaching staff of the Faculty of Geographical Sciences in the first two decades of the 21st century has grown. This allows us to hope that the subsequent years will bring a huge increase in the number of scientific publications significantly using GIS.

In order to learn the attitudes towards GIS, the survey asked if GIS is just a tool used in reaserch. The answers were split in half. Half of the respondents replied positively, but at the same time most of them declared that they think about using GIS in their research when starting studies and posing hypotheses, as well as follow scientific publications that utilise GIS. Interestingly, all respondents who perceive GIS as merely a tool also believe that they are not among the researchers who can be included in GIScience, with one-third of them not seeing a future for such discipline.

The second group (50% of respondents) are "enthusiasts" of GIS, who do not perceive GIS as just a toll, use it at every stage of their research and think that GIScience has a future, even though not all of them include themselves in GIScience.

One of the questions was: Do you think about using GIS when starting a scientific study or posing hypotheses? As many as 90% of respondents answered this question positively, 80% of them check the scientific literature for possible uses of GIS in research in their field, and 90% think that GIScience has a future. Half of the respondents include the acronym GIS or other word associated with GIS (such as software tool) in their keywords, which means that an academic community of GIS users is starting to forming in Łódź.

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