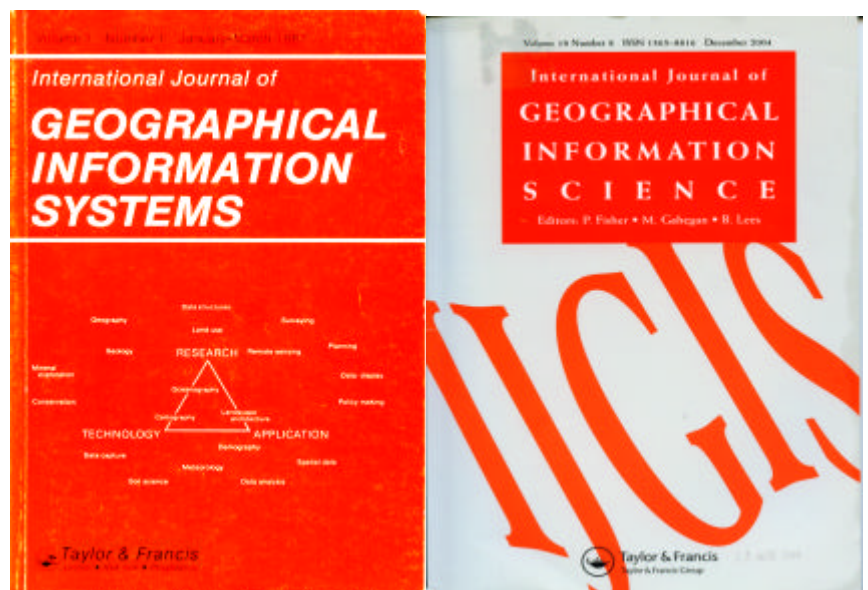


Development of Geographical Information Science in the International Journal of GIS

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To my family, supervisors and friends

Thank you for everything you have been to me.

Abstract

IJGIS has been published continuously since 1987. The founding editors were J. Terry Coppock (Department of Geography, University of Edinburgh) and K. Eric Anderson (Eastern Mapping Center, U.S. Geological Survey). It was one of the first journals dedicated to exclusive publication of research articles in GIS (Geographical Information Systems) as it was emerging as a distinct field of study. Originally named International Journal of Geographical Information Systems [ISSN 0269-3798], the journal included research articles, a News Section (to post information on meetings and developments in GIS), Reviews, and frequently an Editorial addressing some current aspect of GIS. The News Section was eventually dropped and the number of editorials were reduced (Daught, 2004). However, publication frequency steadily increased in the first ten years, allowing for a greater number of research articles to be printed: Quarterly (4 issues/year) 1987-1991; Bimonthly (6 issues/year) 1992-1995; and then 8 issues/year 1996-present.

18 volumes of the International Journal of GIS have been published. These contained 635 research papers, covering 11087 pages. What is published in all research papers of the International Journal of GIS? The research begins with a short overview and introduction of the International Journal of GIS itself. The content of 18 volumes of IJGIS journal is presented, including a general overview and the geographic origin of the authors and the research. Furthermore, the developments of issues and subjects concerning Geographical Information Science over time are described. The average length of the research papers increased rapidly from 14.4 pages in 1987 to 21.4 pages in 2004. The number of authors per research paper slightly increased but still, with increasing number of authors per paper the amount of pages per author decreases.

In general, 51 countries worldwide have cooperated on one or published at least one research paper in the International Journal of GIS between 1987 and 2004. Over time, more countries are involved in the publicity of the scientific journal. The European authors are the most productive in publishing articles during the

research period especially Western Europe. This research gives us an overview not only of development of GIS in general or according to geographical distribution, but also in development from broad scope to specific issues.

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1 Introduction

1.1 Background and problem definition

In the last decade, Geographic Information Science has emerged as a focus of considerable academic attention. To some extent, it is the Earth's New Science, just as Cognitive Science was the Mind's New Science a decade or two earlier (Gardner, 1985). But it is not clear how deep or lasting the impact of GI Science will be, either on academia or on the GIS industry. Rather than following the success of Cognitive Science, GI Science could just as easily be the next Regional Science, a similar fusion of disciplines that peaked early and continues today mainly as an internally successful multidisciplinary field of relatively low influence on science, technology, or society. Worse still, Geographic Information Science could largely be just an artificial name for Geographic Information Systems, and not really a scientific or intellectual field at all.

Geographical Information Systems (GIS) represent a fast growing field lying at the intersection of many disciplines – among them cartography, computing, geography, statistics, surveying and other disciplines concerned with handling and analyzing spatially-referenced data. They are also of interest to a wide and increasing range of users, such as land and resource managers, market researchers, planners, property assessors and those responsible for utilities, to say nothing of administrators and policy makers in departments of government at all levels. Systems have been developed or considered at scales from local to global and for a wide variety of purposes, yet they have many features in common and face many similar problems.

A full definition of GI Science was provided in a report on a workshop held in January 1999 at the National Science Foundation, Geographic Information Science: "Geographic Information Science (GIScience) is the basic research field that seeks to redefine geographic concepts and their use in the context of geographic information systems. GIScience also examines the impacts of GIS on individuals and society, and the influences of society on GIS. GIScience re-

examines some of the most fundamental themes in traditional spatially oriented fields such as geography, cartography, and geodesy, while incorporating more recent developments in cognitive and information science. It also overlaps with and draws from more specialized research fields such as computer science, statistics, mathematics, and psychology, and contributes to progress in those fields. It supports research in political science and anthropology, and draws on those fields in studies of geographic information and society.” (Mark, 2000)

However, the community has not fully adopted such a definition of GI Science as a fundamental research field. Recently, at least in the United States, there has been a tendency to use the term “Geographic Information Science” to refer to almost any academic work that involves Geographic Information Systems (GIS), often without changing the content of conventional “GIS” teaching programs at all. Despite this, it appears that the field has considerable depth, and a richness of intellectual challenges that mark it as a legitimate multidisciplinary field and perhaps an emerging new discipline. Thus, the author is comfortable asserting that GI Science is most certainly not just a new name for GIS training and applications. In a purist view of GI Science, even the use of GIS as a tool in scientific research is not GI Science—at a recent NSF workshop, this latter area was termed “Research Using GIS” (Mark, 2000). Research Using GIS, is important to the sciences, and to funding for GIS-related scientific work, but is not GI Science per se.

The International Journal of Geographical Information Systems/Science represents a source of information on advances and experiences and a meeting place for researchers, developers and operators of systems. Our tendency is to bring a global and geographical view of the GIS as a term and its development by analyzing all research papers published during the eighteen years period.

IJGIS continue to publish the results of GIS researchers. Indeed, some of the trends observed above--particularly the increased frequency of publication, and the accompanying increase in theoretical research--do suggest what

Koehler (2001) (following the rubric of Derek J. de Solla Price) described for Information Science, as a transition in GIS from "small science" to "big science." This research will present a development study of the International Journal of Geographical Information Science (IJGIS), one of the first scholarly journals dedicated exclusively to the interdisciplinary field of Geographical Information Systems (GIS). A greater number of research articles to be printed: Quarterly (4 issues/year) 1987-1991; Bimonthly (6 issues/year) 1992-1995; and then 8 issues/year 1996-present. These trends indicated a settling-in of the journal's purposes, a formalization of the journal's readership network, and a maturing of the GIS field itself. While more recent Editorials are intended to "check-in" with readership about trends and developments or to introduce special issues (often with guest editors), earlier ones sought to "educate" the readership as to what to expect from the journal (Daught, 2004). In addition, this will give us a historic and geographic overview of the number of papers published and authors per paper, analyzing the number of papers in terms of Geo-Information Science's issues, and the impact of IJGIS in Geo-Information literature according to implemented classification criteria. Moreover, I have chosen these classification criteria considering different points of view, directions, issues and theories of the research, starting from main focus, and through GIS application to specific Geo-information issues.

In the first issue, T. R. Smith (1987) presented a well-received overview of the GIS field. One of the main goals of this thesis is to provide some a broad overview of aspects of the field or developments in different countries in International Journal of Geographical Information Systems.

Since 1987, many Geo-information oriented journals such as Cartographical, Transaction in GIS, Cartography and GIS, The International Journal of Geographical Information Science, Geographical Analysis, Geographic Information Sciences, International Journal of Remote Sensing, Journal of Spatial Science, Photogrammetric Engineering and Remote Sensing, URISA Journal, Computers and Geoscience were published.

Why did I choose IJGIS for this Geo-information development research? Initially, I considered the publication period, regularity, frequency and broad range of topics concerning GI orientation published in research papers.

1.2 Objectives

The main objective of this research is to describe and analyze trends of Geographical Information development in Geo-Information society (environment/ application) by analysis of International Journal of Geographical Information Science in its 18 volumes (from 1st January 1987 until 31st December 2004)

The main goal of this study is three-fold:

- To analyze the development within the International Journal of GIS from geographical and statistical point of view (historic and geographic overview)
- To explore and describe trends in research papers of The International Journal of GIS development considering classification criteria
- To examine Geo-Information development from various perspectives such as cooperation, new GI issues introduced over the years

1.3 Report outline

This report will basically follow the framework graphically simplified in figure 1. In introduction (chapter 1) the background, problem definition and the research objectives are described. In chapter 2 the methodology with its introduction will be discussed. In chapter 2 more detailed description of methodological steps, and also decisions taken during data acquisition will be discussed. In methodological steps the interest to data selection, classification criteria and data collection will be given. In data acquisition the decisions taken dealing with authors, different continents and countries will be described. In chapter 3 the developments of GIS in IJGIS will be derived. In chapter 3 developments considering authors, pages and research papers will be presented. In chapter 3 also the geographical distribution will be presented

and described. The last part of this chapter will be dedicated to the content of research papers published. Particularly the main focus, the application field, earth sciences, “the five bullets” of NSF solicitation and GI issues will be presented and described. In the last chapter conclusions are presented.

2 Methodology

2.1 Introduction

In this chapter the methodology that is used to present worldwide development of GIS in the International Journal of GIS is described. The methodology consists of the following steps: data selection, classification criteria, data collection, data analysis and result representing Geo-information development.

2.2 Methodological steps

The goal of this section is to describe data analysis to answer research objectives stated in the previous chapter. In Figure 1, the methodological steps are described in more detail. This consists of the following main steps: data selection, data collection based on classification criteria, and development of IJGIS as result derived from data analysis. Classification criteria consist of general attributes, geographical attributes and with the largest domain called content attributes. I will pay attention to the description of already mentioned steps in the following paragraphs.

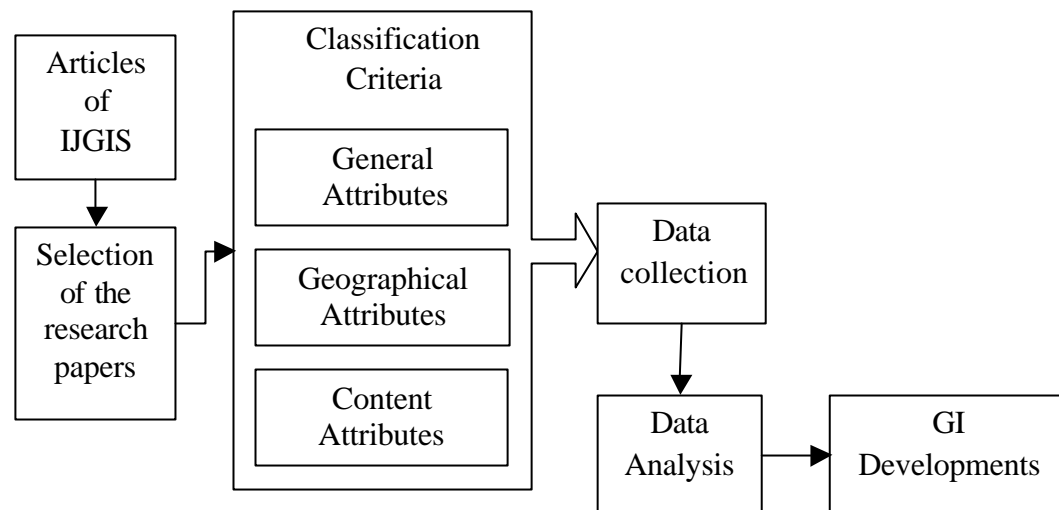


Figure 1 Methodological steps to explore development of IJGIS

2.2.1 Data selection

In this section, the appropriate research papers were selected from all the articles in eighteen volumes of International Journal of GIS. Only research articles (635 research papers) were taken into account. Several contributions of the International Journal of GIS as Editorials, Guest Editorials, Editorial reviews, Prefaces, Forewords, Publication Lists, Comments, Replies, Book Reviews, Letters, New Sections, Forthcoming Events, Conference Announcements, Index of authors and Conference Reports were excluded from further research. These played not just a revealing role in different volumes of IJGIS but were also were a helpful tool for overview and summarizing the main goal of an article before reading the article itself (Editorials and Guest Editorials).

In the International Journal of GIS special volumes called “Special Issues” were also published. These were treated and classified in the same way as research papers. Some of the issues have a special role in IJGIS, and focus on recent topics within Geographical Information Science. They have positively influenced the development of the journal. It was especially by growth in number of authors, higher number of papers and also pages per volume published.

2.2.2 Classification criteria

Before starting with data collection by reading different articles, I had to set up classification criteria which are threefold and consist of general attributes, geographical attributes and content attributes. In Table 1, components of the classification criteria from broad division as domains into more specific variables are presented.

Table 1 Components of classification criteria

DOMAINS	GROUPS	VARIABLES
General attributes		Code
		Volume
		Issue
		Paper per Issue
		Year
		First author
		Initial
		First page
		Last page
		Number of pages
		Cumulative number of pages
		Number of authors
	Geographic	Origin of authors
N America		
C/S America		
Africa		
Asia		
Oceania		
Origin of authors (countries)		1 - country ISO code(%)
		2 - country ISO code(%)
		3 - country ISO code (%)
Origin of research		Europe
		N America
		C/S America
		Africa
		Asia
		Oceania
		Generic
		Global
		None
		Origin of research (countries)
2 - country ISO code (%)		
3 - country ISO code (%)		
General (more than 3 countries)		
	None	
Content attributes	Main focus	Research
		Technology
		Application
	Type of research	Application
		Methodological/Conceptual
		Review
	Spatial data handling	Data capture
		Data structuring
		Data analysis
		Data display
		None

DOMAINS	GROUPS	VARIABLES
	Spatial dimension (SDI)	Local level
		State level
		National level
		Regional level
		Global level
		None
	Application	Agriculture/Forestry
		Economics and Business
		Environment and Ecology
		Earth Sciences
		Social Sciences
		Policy making
		Natural hazards and disasters
		None
		Multidisciplinary Sciences (yes/no)
	Earth Sciences	Soil science
		Geology
		Petrology/Mining
		Meteorology
		Spatial planning/ Landscape architecture
		Land use
		Hydrology
		None
	"Five bullets" in NSF	Spatial analysis and spatial statistics
		Spatial relations and database structures
		Artificial intelligence and expert systems
		Visualization
		Social, economic and institutional issues
		None
	Urban/Rural	Urban
		Rural
		Both
		None
	GIS Components (organizational geo-wares)	Software
		Hardware
		Humanware
		Dataware
		Orgware
		None
	Space and time	Space
		Time
		Both
None		
GI Issues	Spatial data quality(accuracy, errors,	
	Geo-computation	
	Geo-database	
	Spatial data infrastructure	

DOMAINS	GROUPS	VARIABLES
		Topology
		Remote Sensing
		GPS
		Photogrammetry
		Cartography
		DEM
		Ontology
		Spatial modelling
		Surveying
		Spatial statistics
		Data management
		Scale
		Various
		GIS

I have divided classification criteria into domains, groups and variables. In Table 1, the division of domains such as geographic attributes, general attributes (Hartemink et al., 2001) and content attributes and their groups is shown. Last content attributes were classified on the basis of definitions (see Appendix B)

In the next paragraphs, I will describe attribute groups which were used as the outline for further analysis of research papers.

All scientific papers published between January 1987 (vol.1, issue 1) and December 2004 (vol.18, issue 8) were classified according to the following groups:

General attributes. (code, volume issue, paper per issue, year, the first author's name, the first and last page of each paper, number of pages, cumulative number of pages, number of authors)

Origin of the author(s). All continents were included: Europe, North America, Central and South America, Africa, Asia, Oceania.

Origin of the author(s) (country). Maximum three countries were listed in case of international cooperation. To know the origin of author per country the ISO Alpha 3-coding was implemented according to methods and

classifications of Statistics division of the UN (United Nations).
<http://unstats.un.org/unsd/methods/m49/m49alpha.htm>

Origin of the research. All continents were listed and also generic, global classes were added as follows: Europe, North America, Central and South America, Africa, Asia, Oceania, Generic, Global, None, General (more than three countries).

Origin of research (country) according to country division was set in the same way as the origin of authors (countries)

<http://unstats.un.org/unsd/methods/m49/m49alpha.htm>. Due to research applied in more than three countries in one research paper in some cases, an extra class called 'General' was implemented.

Main focus of research papers

The IJGIS Triangle, which is established as main content in introducing International Journal of GIS, has been considered as main focus and a starting point of content attributes. As is shown in Figure 2, the 'IJGIS Triangle' has been displayed on the title page of first four IJGIS volumes only. The main trend of GIS considering Research, Technology and Application from year 1987 to 2004 will have to be investigated.

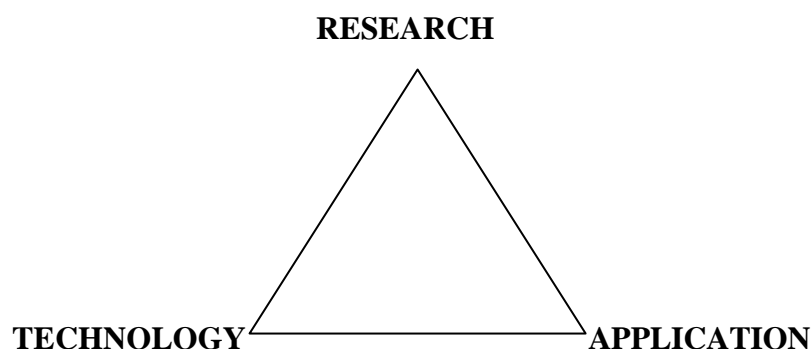


Figure 2 IJGIS Triangle according to the first publication of the IJGIS (Coppock, 1987)

Type of the research Three types of research were distinguished: Application (on purpose to solve specific, practical questions; its primary aim is not to gain knowledge for its own sake); Methodological/Conceptual (study approaches

and conceptual discussions); Review (Existing research gathered from different sources)

Spatial data handling consists of data capture, data structuring, data analysis and data display as follows:

Data capture Any operation that converts digital or analogue data into computer-readable form. Geographic data can be downloaded directly into a GIS from sources such as remote-sensing or GPS data, or it can be digitized, scanned, or keyed in manually from paper maps or photographs. (<http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.search&searchTerm=data%20capture>)

Data structuring Is the organization of data within a specific computer system that allows the data to be stored and manipulated effectively; a representation of a data model in computer form. (<http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.search&searchTerm=data%20structure>)

Data analysis is the act of transforming data with the aim of extracting useful information and facilitating conclusions. Depending on the type of data and the question, this might include application of statistical methods, curve fitting, selecting or discarding certain subsets based on specific criteria, or other techniques. Data visualization is sometimes an important part of data analysis, especially in the case of explorative data analysis (http://en.wikipedia.org/wiki/Data_analysis)

Data display visible representation of data on a console screen in the form of a report, graph or drawing (<http://wgiac2.state.wy.us/html/whatisgis.asp>)

Spatial dimension According to SDI (Williamson, Rajabifard and Feeney, 2003) five different levels are used: Local, State, National, Regional, and Global. The research papers without any dimension are classified as “none”.

Application of the Research The following classes used were: agriculture and forestry; economics and business; environment and ecology; earth sciences, social sciences; policy making; natural hazards and disasters; multidisciplinary sciences (more than one of the mentioned application fields present). These application fields were implemented and selected from the ISI Web of Science.

Earth Sciences Its classes were chosen regarding to Web of Science (ISI). Following sciences were considered: Soil Science; Geology; Petrology; Meteorology; Spatial planning and Landscape architecture, Land use; Hydrology

“The five bullets” in NSF solicitation

The National Science Foundation (NSF) solicitation was written by Abler for a National Centre for Geographic Information and Analysis (NCGIA) after meeting with members of the GIS and quantitative geography research communities (Abler, 1987). He saw in NSF support for a science and technology research centre more devoted to GIS. The scientific core of NSF solicitation for a NCGIA became known as “the five bullets”. In these “five bullets” the following topics were distinguished:

- spatial analysis and spatial statistics;
- spatial relations and database structures;
- artificial intelligence and expert systems;
- visualization;
- social, economic and institutional issues

Urban and Rural Group paying attention only to Urban, Rural, Both or None perspective to know if the papers were focusing on Urban or Rural areas in different countries in their application field

GIS Components (organizational geo-wares) The five organizational geo-wares in a multi-systems environment were distinguished (Kok, 2003) Software, Hardware, Humanware, Dataware, Orgware. The class for none of mentioned geo-wares was added to this group.

Space and time Almost all research papers are focusing on space element; sometimes only time element plays a role. Therefore I have to consider if I keep this group in implemented “Classification Criteria”.

GI Issues They have been chosen according to interest of subjects present within Geo Information and already developed different GI fields. Spatial data quality (accuracy, errors, uncertainty); Geo-computation; Geo-database; Spatial Data Infrastructure; Topology; Remote Sensing; GPS; Photogrammetry; Cartography; DEM; Ontology; Spatial Modelling; Surveying; Spatial Statistics; Data Management; Scale; GIS;

2.2.3 Data collection

In this section I will focus on how to collect data. In comparison of research in the IJGIS to the similar research done in Geoderma (Hartemink et al., 2001) I can notice the absence of keywords in all the IJGIS and also missing digital format of the IJGIS volumes from 1987 to year 1997. This means that ten years of ten volumes are not possible to analyse from digital format either. The possibility is to collect data by reading the selected scientific articles.

Data of the IJGIS were collected by considering following conditions/criteria:

- **Percentage distribution.** A value of 100 was assigned to each group and divided. This method was applied for authors from different continents and countries, or in case the research paper was dealing with more than one class.
- **Retrieving statistical information** about general attributes derived from headings of each research article.
- **Reading research papers** starting from abstract till references by assigning 100 percent to each group of variables and at the same time distributing them within variables of current group.

For data collection it was necessary to create an IJGIS spreadsheet consisting of all attributes (general, geographical and content). These were placed into columns and list of records (635 research papers) with its unique

code in rows. The IJGIS spreadsheet is a final source of all information about each research paper collected.

To edit all the data, the IJGIS spreadsheet was adequate for retrieving and editing statistical information but insufficient and unclear for editing/during reading research papers. On this purpose of clarity in inserting (easier manual/analogue editing) data in analogue way by reading articles, three IJGIS forms were implemented. These are the partially transposed IJGIS spreadsheet. After printing the IJGIS forms, the research papers were classified. All data were written into the IJGIS forms. In Table 2 the example (partly) of the IJGIS form is shown.

Table 2 Example of IJGIS form

	Code	1	IJGIS010101
Volume	2		1
Issue	3		1
year	4		1987
first page	5		13
last page	6		31
First author	7		Smith
Initial	8		T R
Origin of the research	Europe	9	
(continents)	N America	10	
	C/S America	11	
	Africa	12	
	Asia	13	
	Oceania	14	
	Generic	15	
	Global	16	
	None	17	100
Origin of the research	1 - country ISO code	18	
(countries)	%	19	
	2 - country ISO code	20	
	%	21	
	3 - country ISO code	22	
	%	23	
	General (more than 3 countries)	24	
	None	25	100
Main focus	Research	26	
	Technology	27	50
	Application	28	50
Type of the research	Application	29	
	Methodological/Conceptual	30	
	Review	31	100

After the data retrieval three IJGIS forms were transposed into one final IJGIS spreadsheet. Finally, the IJGIS spreadsheet was checked by making statistical and analytical/systematic checks.

Before approaching the last steps of IJGIS, methodological steps still need to be mentioned and some facts and practical procedures taken into account. These actions are described according to authors, continents and countries (origin of authors/research), author's and country's division.

2.3 Decisions during data acquisition

2.3.1 Authors

Authors originated in China are having their first names and surnames in opposite order. In case of Chinese authors, it is also necessary to take into account the possible redundancy of initials with the surname of author I wrote down instead of initials of author's complete first name. This was applied just for authors publishing articles in China.

2.3.2 Continents and countries (origin of author/research)

In few cases, some authors have published scientific papers for different continents or countries. I had to be careful about which are influenced in the most cases by the origin of research and origin of the author that I included in our classification. Another problem was that some authors were publishing their articles while being in other country.

In some research papers, I can find the origin of the author under the country which was united with other country or the other way round (case of USSR). Our decision is to keep origin of countries like they were in the past and if new countries appeared, I assign them the present name with its ISO Alpha-3 country code. In the past, many countries were not part of other countries e.g. Hong Kong was not considered as part of China before, South and North Korea as a Korea with abbreviation code KOR.

2.3.3 Author's and country's division

In the following paragraph and Figure 3, and the percentage division is described. To make the percentage division in proper equal way, I have applied method of 100% dividing within the amount of authors and if one author was publishing his research paper in more than one country I have divided the amount of percentage into 2 or more countries. This could be done in different ways, but I found this division the most suitable and more proper for IJGIS development than the other possible percentage divisions.

Percentage of amount of countries is divided according to percentage of amount of authors. More cases occurred in the research considering amount of authors and amount of countries. There is a possibility that same amount of authors and the same amount of countries occur but with redundancy of one or more countries.

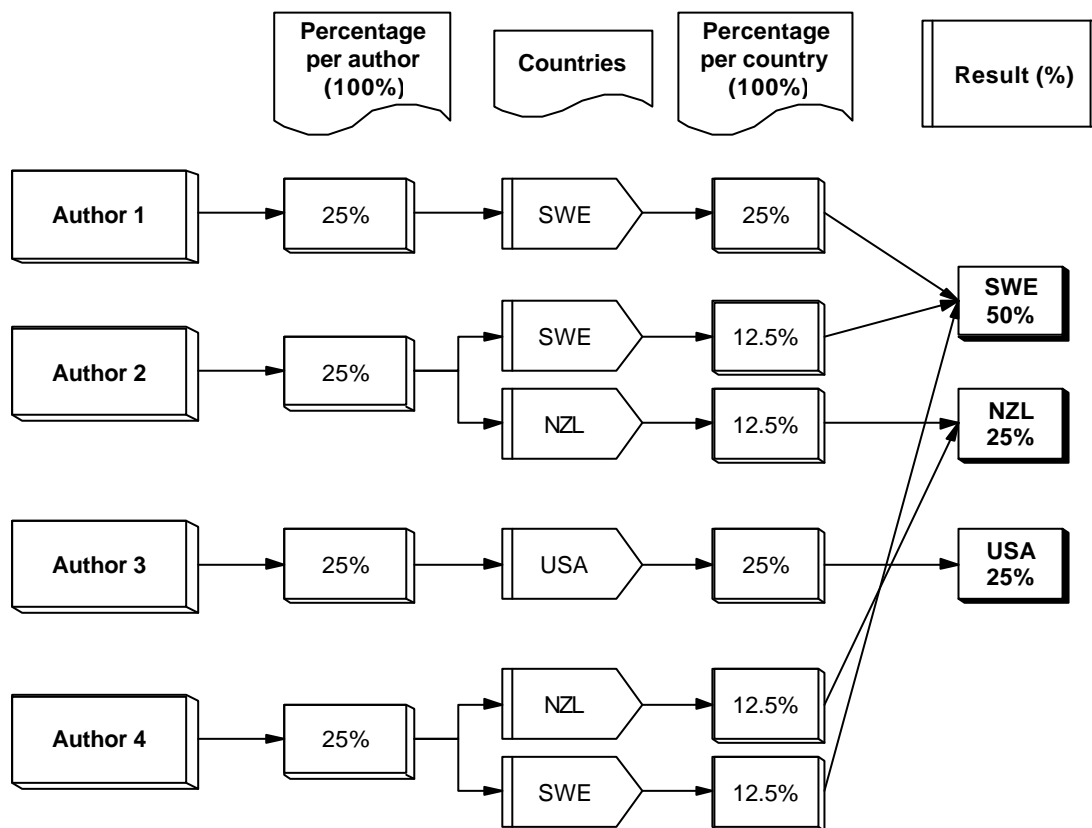


Figure 3 Example of authors' and countries' division

Finally, I can come up with results that will give us more detailed impression about worldwide development of Geo-Information Science in the International Journal of GIS between years 1987 and 2004.

In the next chapter, I will focus on development of GIS in IJGIS regarding only specific groups of classification criteria (see Table 1 in chapter 2.2.2).

3 Results - Developments from outside to inside

To explore the GI development from a broad sight to specific issues for this purpose, the following classification criteria were selected:

- Authors, pages and papers (general distribution);
- Geographical distribution;
- Content of research papers

Due to large amount of data and classification criteria, the above listed groups from classification criteria were selected for further study. In case of authors, pages and papers the focus was concentrated on amount of authors, pages, papers and also relation between them over the years (between 1987 and 2004). Particularly, a total number of papers, pages and authors, an average number of pages per paper, an average number of authors per paper, an average number of pages per author.

Within the geographical distribution, the attention was paid to origin of authors and origin of research per continent and country over the years and per whole research period of 18 years. Special attention in this section was paid to international research made according to origin of authors.

Summary of main domains and their focus:

Authors, pages and papers:

- Total number of papers, pages, authors
- Total number of pages per paper
- Total number of authors per paper
- Total number of pages per author

Geographical distribution

- Origin of the authors (continents, countries)
- Origin of the research (continents, countries)
- Continental or intercontinental research (according to origin of authors)
- National or international research (according to origin of authors)

Content of research papers

- Main focus
- Application and earth sciences
- Five bullets of NSF solicitation
- GI-issues

3.1 Authors, pages and papers

Within general distribution, the numbers of authors, pages and papers are described. More detailed interaction between them is explored in the next paragraph. Exactly, the relation between the average amount of authors and papers, pages and papers, and pages and authors is further depicted.

I expect total number of authors, pages and papers to have increasing trend during whole research period from early period till present. The reason for this potential growth is caused by increase of number of issues from four issues yearly (1987 - 1992) then to six issues yearly (1992-1996) and as last increase to eight issues per year (1996-2004) within the research period.

3.1.1 Authors

Generally, the total number of authors publishing papers in IJGIS is increasing (see Figure 4). I can distinguish three phases of development in amount of authors publishing research papers. In the first preliminary phase (1987-1990), the number of authors was the least approximately 40 authors yearly. Second phase is intermediate (1990-1996) and the last one is the expanding from year 1996 up till the end of research period (2004). Significant changes in number of authors publishing articles can be observed in years 1996 and also 1999.

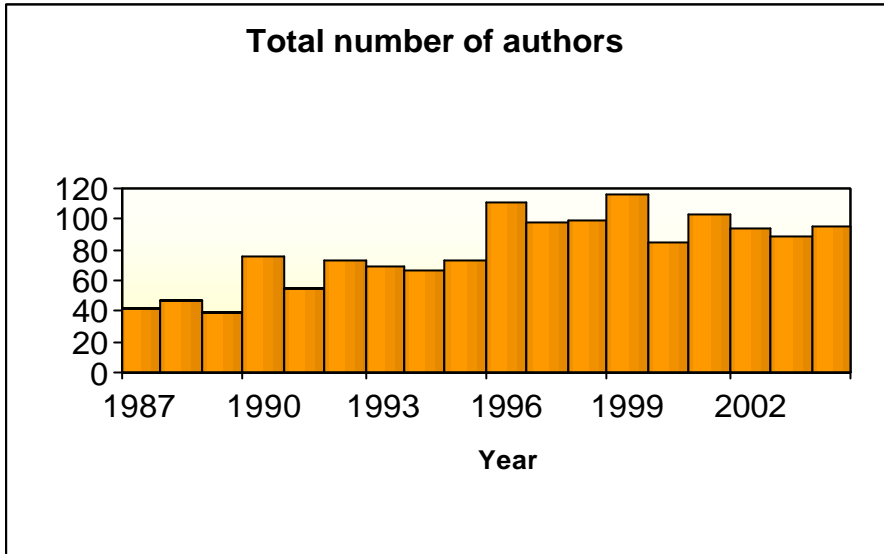


Figure 4 Number of authors per year between 1987 and 2004

3.1.2 Pages

In Figure 5, the overview of temporal change of number of pages is displayed. In first three years the number of pages was just low and initial. Amount of pages had expanding character till 1995. Significant changes in number of authors publishing articles can be observed in years 1990, 1996 and also 1999.

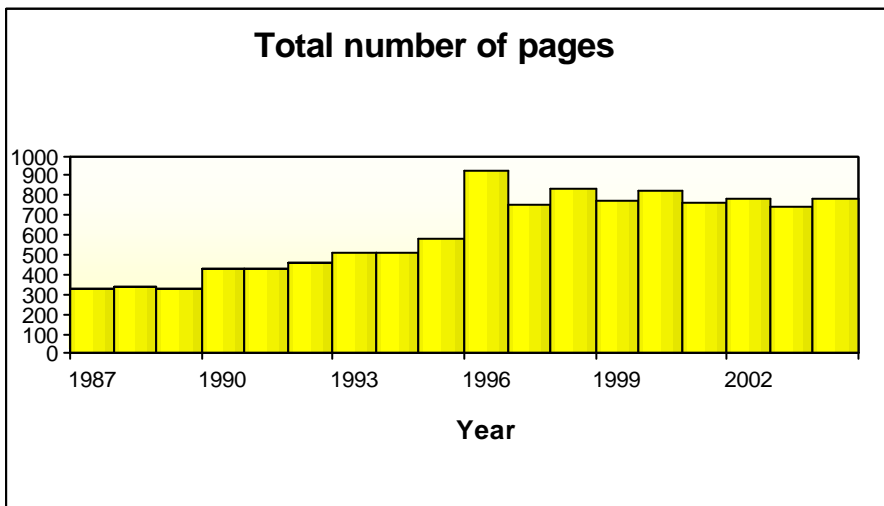


Figure 5 Number of pages per year in IJGIS between 1987 and 2004

3.1.3 Research papers

In Figure 6, I can see that the amount of published papers is increasing and the highest numbers of papers are obvious in 1996. This could be influenced by 10th anniversary of the IJGIS and on the other hand with edition of two 'Special Issues' in volume 10 (issue 1 and issue 6). Total number of papers during last two years have slightly decreasing trend.

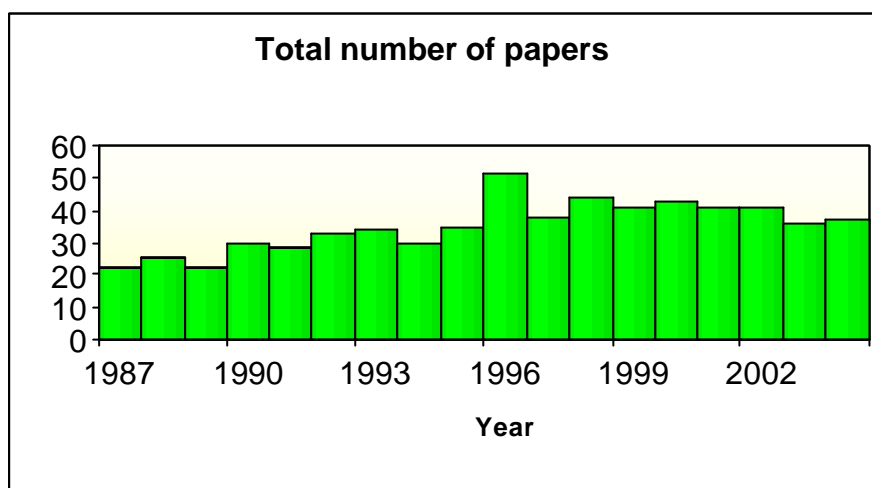


Figure 6 Number of research papers per year in IJGIS between 1987 and 2004

3.1.4 Authors per paper

In general, average number of authors per paper increased from 1.90 in 1987 to 2.56 in 2004. The large increase is in 1999 with 2.85 authors per paper, followed by year 1997 with its average of 2.59 authors per year. The lowest amount of authors per paper in average is in 1989 with its 1.66. In Figure 7, I can observe increasing number of authors in year 1996 which is caused by increased number of volumes from 6 to 8 volumes per year. With increasing average number of authors per paper, the number of pages per author is decreasing. Strategic years in IJGIS became 1992 and 1996 with growth of the volumes. In the first publications from 1987 till 1992, four volumes were published. Later in 1992 amount of volumes is growing to six per year and finally in 1996 rising to eight volumes per year.

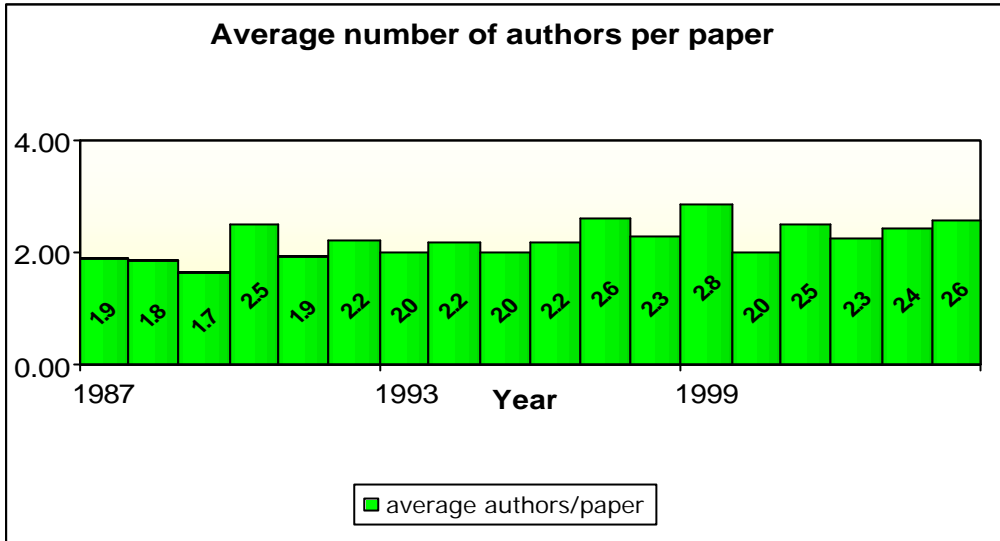


Figure 7 Average number of authors per paper yearly in IJGIS between 1987 and 2004

3.1.5 Pages per author

In Figure 8, the average number of papers per author is presented. I see that over the period the average value of about 8.5 did not change much over the years. Only in years 1994 and 1999 had reduced number of pages per author significantly.

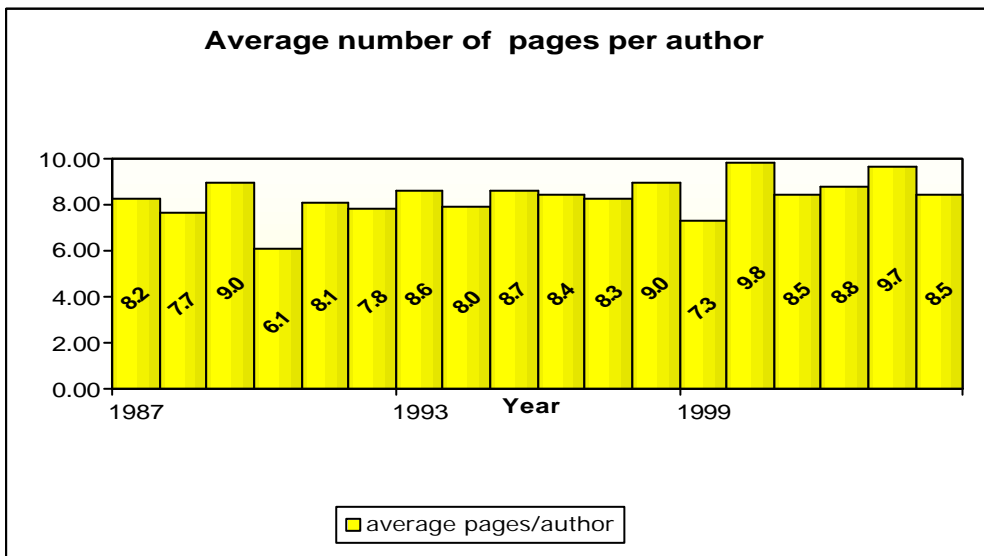


Figure 8 Average number of pages per author yearly in IJGIS between 1987 and 2004

3.1.6 Pages per paper

In its 18 volumes, authors of research papers in IJGIS have published in total 635 papers which represent 11087 pages in period from year 1987 until 2004. The number of pages and papers increased rapidly from year 1996 compared with the number of pages and papers from the preceding years. The relationship between the number of pages and papers published in the research period over time in IJGIS is shown in Figure 9. The number of pages per paper increased from 14.42% in 1987 to 21.38% in 2004. Relatively high number of pages per paper is in year 2003 on average 20.88, 1997 with 20.11 and 1999 with its 19.47. It is important to mention that average amount of pages per research paper is increasing since 1997 when the name of the journal was changed from the International Journal of Geographical Information Systems to the International Journal of Geographical Information Science (Fisher, 1997).

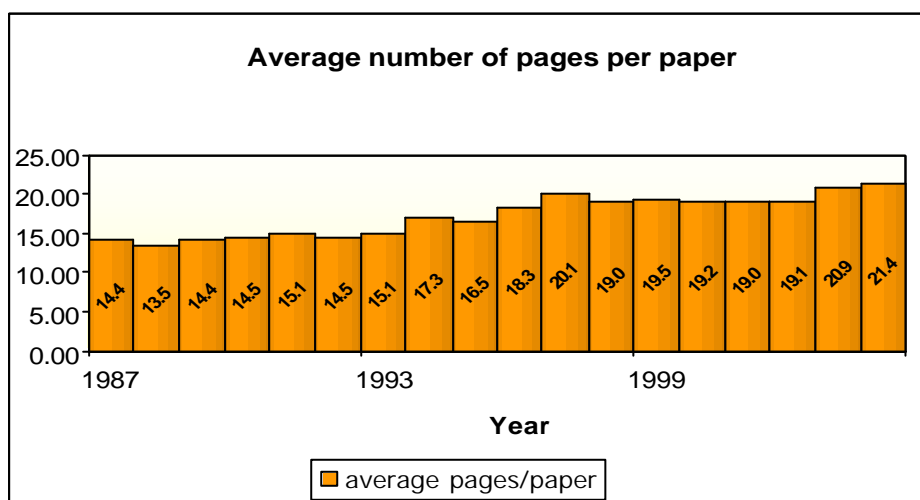


Figure 9 Average number of pages per paper yearly in IJGIS between 1987 and 2004

3.2 Geographical distribution

In this section the geographical overview according to the origin of author and research of published papers in IJGIS is explained. At the end of this paragraph I focused on the papers from different aspect/perspective. I depicted the research papers according to continental or intercontinental, national or international development in case of origin of authors.

3.2.1 Origin of authors

In general most authors publishing papers in IJGIS are coming from “Anglo Saxon” Countries, not only because IJGIS has been English journal but also because all the research papers have been written in English and the journal is British.

From Table 3 it is obvious that the majority of authors publishing research papers originate in Europe or North America. During whole research period between 1987 and 2004, the leading authors originated in Europe with approximately 42.48 %. Just below this follow authors from North America with 38.03 %. Further behind follow authors from Oceania with 9.44% followed closely by authors from Asia with 8.51% published papers. Then follow Central and South America with only 1% of overall published papers. Africa is placed with lowest number of authors, only 0.55%.

Table 3 Overall origin of authors per continent between 1987 and 2004

Rank	Origin of authors (continent)	Total papers (%)
1	Europe	42.48
2	N America	38.03
3	Oceania	9.44
4	Asia	8.51
5	C/S America	1.00
6	Africa	0.55
<i>Total</i>		100.00

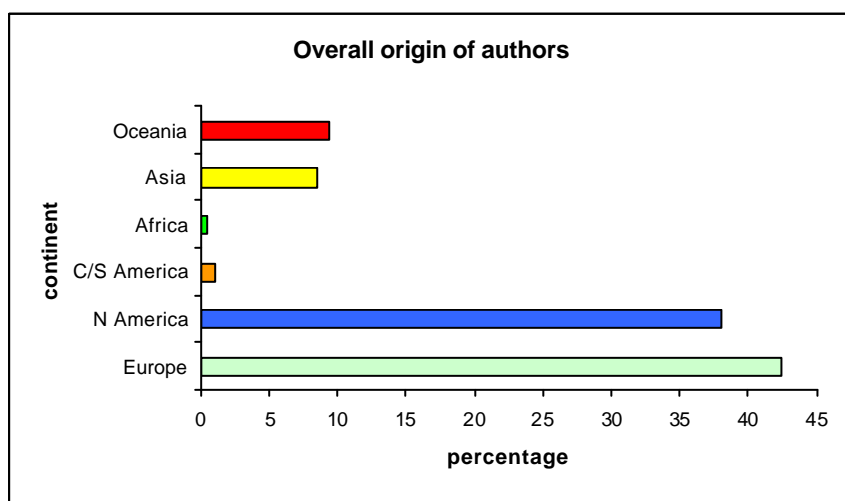


Figure 10 Overall origin of authors according to continents in IJGIS between 1987 and 2004

In Table 4, the origin of authors according to different continents is presented.

All four issues of the first volume were published by authors from three continents which were North America, Europe and Asia. The authors from Oceania started to publish articles from year 1988. The majority approximately 52% of research papers was published by North American authors, then by the Europeans (35%) and the Asians (13%). Between 1987 and 2004, the fluctuation and competing trend between continents is obvious, especially between the two dominant continents North America and Europe, then between Asia and Oceania. In year 1987, more than half of research papers were written by authors from North America. In the last two years (2003, 2004) is obvious increasing trend of research papers. The authors from North America were more productive in publishing articles in beginning of 90's (1990, 1991, 1993 and 1995). In the last period, I can observe the decreasing amount of published papers for North Americans and increasing amount of papers for the Europeans. In the last period, year 1998 and from 2000 to 2004, Asian authors are rapidly increasing their amount of publications. Oceania is just behind Asia in last 2 years, with authors from Central and South America far behind. Last are sited authors from Africa.

Table 4 Origin of authors according to continents per year between 1987 and 2004

Origin of the author (continents) in %						
Year	Europe	North America	C/S America	Africa	Asia	Oceania
1987	34.78	52.17	0.00	0.00	13.04	0.00
1988	69.23	19.23	0.00	0.00	0.00	11.54
1989	34.78	30.43	4.35	0.00	17.39	13.04
1990	40.00	43.33	0.00	0.00	0.00	16.67
1991	15.52	63.79	0.00	3.45	10.34	6.90
1992	52.83	41.11	0.00	0.00	0.00	6.06
1993	25.00	57.35	0.00	0.00	8.82	8.82
1994	58.06	29.72	0.00	0.00	2.22	10.00
1995	34.29	53.33	0.00	0.00	0.95	11.43
1996	60.13	32.03	0.00	0.00	1.96	5.88
1997	43.42	34.87	2.63	0.00	4.61	14.47
1998	37.88	37.12	0.00	0.00	16.10	8.90
1999	48.13	31.95	0.00	0.00	6.30	13.62
2000	33.33	41.78	2.33	0.00	15.58	6.98
2001	46.75	21.95	2.44	0.00	17.89	10.98
2002	31.46	39.27	4.88	3.66	8.54	12.20
2003	47.69	29.40	0.00	2.78	11.81	8.33
2004	51.35	25.68	1.35	0.00	17.57	4.05

3.2.2 Origin of research

Origin of research was invented to know more where the location of research papers applied. Which continents were as an object of application? I can explain which study areas within the continent were selected for application of research. Research was applied (case study, field work) on exact study area, which is part of country and country part of continent. In this paragraph, I will focus more on group 'origin of the research' looking at continents. Even more three variables (global, generic and none) have been added due to articles without any field of research application. Here is a difference in comparison with group 'origin of authors per continent'. In Table 5, the highest percentage 32.7 is assigned to "None" followed by Europe 21.4 %, North America 15.5%, "Generic" occupies the fourth place with 12.5%, and then Asia with 6.9% took place before Oceania with 5.0%. Just behind is placed "Global" (3.0%). The last two continents focusing on research's origin are Africa (1.7%) and Central and South America.

Table 5 Overall origin of research according to continents between 1987 and 2004

Rank	Origin of research (continent)	Total papers (%)
1	None	32.72
2	Europe	21.35
3	N America	15.46
4	Generic	12.48
5	Asia	6.94
6	Oceania	5.04
7	Global	2.98
8	Africa	1.72
9	C/S America	1.30
<i>Total</i>		100.00

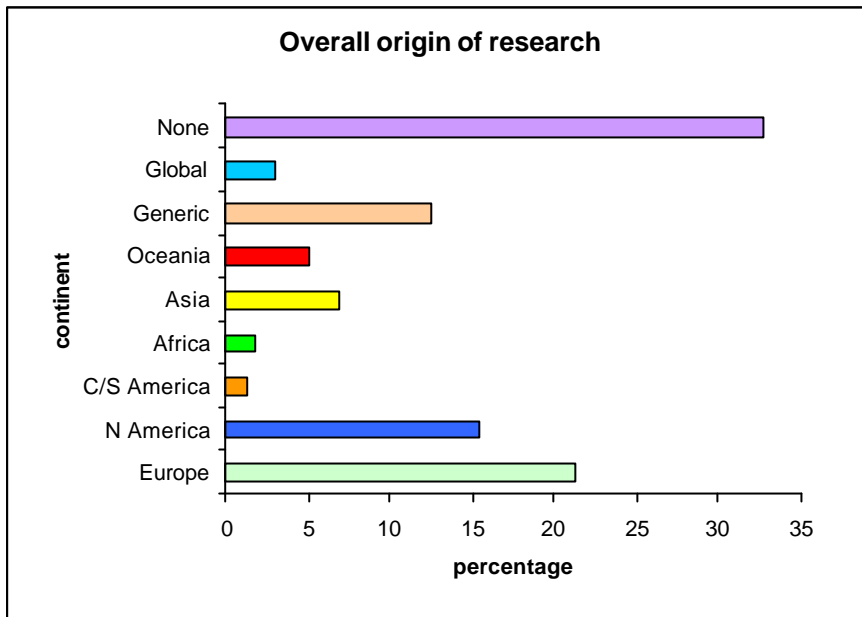


Figure 11 Overall origin of the research according to continents in IJGIS between 1987 and 2004

In comparison between origin of the author and the origin of the research over the years, I can observe similar trends. So I expect that the authors from the exact continent are concentrating to apply their experiments or research within the same continent. Trends in origin of the research and origin of the author(s) are almost the same. In the origin of research, I have added Generic, Global and None class where the increasing trend is significant in “None”, decreasing trend for whole research period from 1987-2004 for Generic class and stagnating Global class. None class is representing the no field of research application. It is the variable having the highest number of papers. This could be a result of more papers written on research purpose. (European authors has majority in writing articles focusing on research.)

Table 6 Origin of the research (continents) per year between 1987 and 2004

Origin of the research (continents) in %									
Year	Europe	North America	C/S America	Africa	Asia	Oceania	Generic	Global	None
1987	26.09	19.57	0.00	0.00	13.04	0.00	4.35	4.35	32.61
1988	40.38	7.69	0.00	0.00	0.00	7.69	40.38	3.85	0.00
1989	17.39	8.70	4.35	0.00	4.35	8.70	21.74	0.00	34.78
1990	20.00	13.33	0.00	1.67	5.00	10.00	13.33	3.33	33.33
1991	6.90	17.24	3.45	10.34	17.24	3.45	6.90	0.00	34.48
1992	9.09	18.18	0.00	0.00	3.03	3.03	12.12	9.09	45.45
1993	11.76	29.41	0.00	0.00	8.82	2.94	11.76	2.94	32.35
1994	13.33	16.67	0.00	0.00	0.00	3.33	36.67	0.00	30.00
1995	23.81	11.43	0.00	2.86	7.62	5.71	14.29	2.86	31.43
1996	31.37	21.57	0.00	0.98	2.94	3.92	7.84	5.88	25.49
1997	23.68	15.79	0.00	0.00	5.26	10.53	10.53	2.63	31.58
1998	15.91	18.18	0.00	0.00	11.36	2.27	6.82	0.00	45.45
1999	26.83	7.32	1.22	0.00	4.88	9.76	7.32	3.66	39.02
2000	23.26	20.93	4.65	6.98	9.30	2.33	4.65	2.33	25.58
2001	23.17	7.32	2.44	2.44	10.98	7.32	2.44	7.32	36.59
2002	21.95	14.63	0.00	4.88	4.88	9.76	9.76	0.00	34.15
2003	27.78	22.22	2.78	0.00	2.78	0.00	11.11	0.00	33.33
2004	21.62	8.11	4.50	0.90	13.51	0.00	2.70	5.41	43.24

3.2.3 National and International research papers

In Table 7, the amount of 547, which means 86.14% articles regarding to origin of author were published within the author's home; it means that a value of 100 was fully assigned to the specific country in the article. Only 13.86% of total amount of research papers were published at the international level.

Table 7 Overall number of national and international papers (%) according to origin of author between 1987 and 2004

International and national papers		
Origin of authors country	no of papers	%
International	88	13.86
National	547	86.14
Total	635	100

In order to distinguish whether the trend of research papers regarding to origin of authors is more national or international, I had to assign 100 percent to all national countries present. The same will be applied to countries with international cooperation. I will focus on international development over time between 1987 and 2004.

The trends in cooperation between different countries considering origin of authors are presented in Figure 12 and Figure 13. The most articles were

published on the national level and less on the international level. First indication about the international cooperation in IJGIS started in year 1990 and continued until 2004 and has growing trend in number of countries cooperating and also in amount of articles published. The most research papers were published in USA with 31.54 percent followed by Great Britain (21.04%) and further behind Australia (7.64%), the Netherlands (6.63%) and Canada (5.91%) (See Appendix B). The information on countries involved in different levels is also summarized. In Appendix B is shown the number of countries publishing in IJGIS internationally (38) and nationally (21).

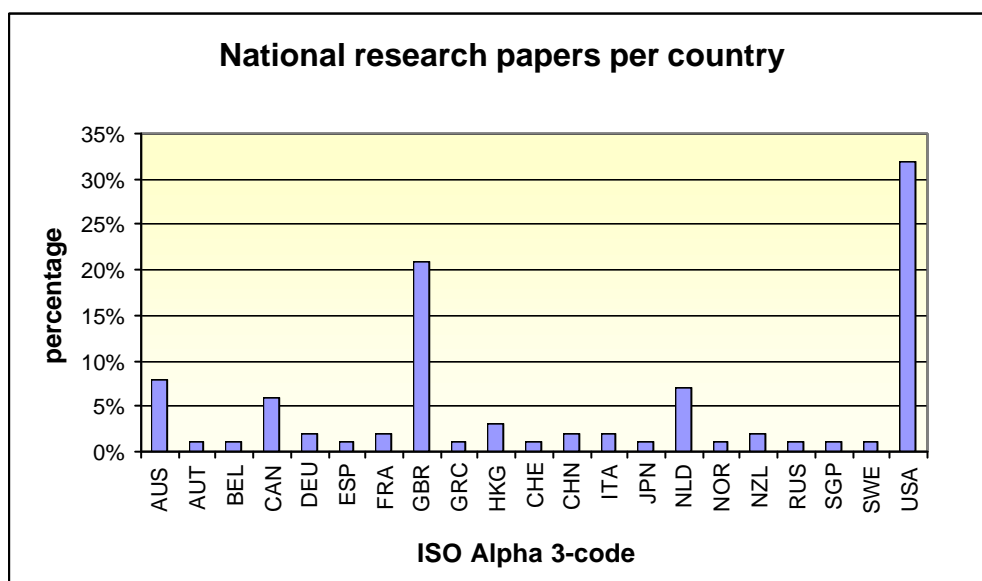


Figure 12 National research papers according to origin of authors per country in IJGIS between 1987 and 2004

To explore the development of GIS at the international level I have to pay more attention to the following figure. USA (20.4%), the most active in this direction, is followed by Great Britain (9.2%) and then by Canada (9.0). Surprisingly, Hong Kong with its 8.2 % is more productive than Australia and Netherlands. Just behind is placed China with 5.1 %. Nowadays, Hong Kong belongs to China. This fact has an impact on results and plays important role for China in the international cooperation. Then china including Hong Kong will take the second place after USA with 13.3%.

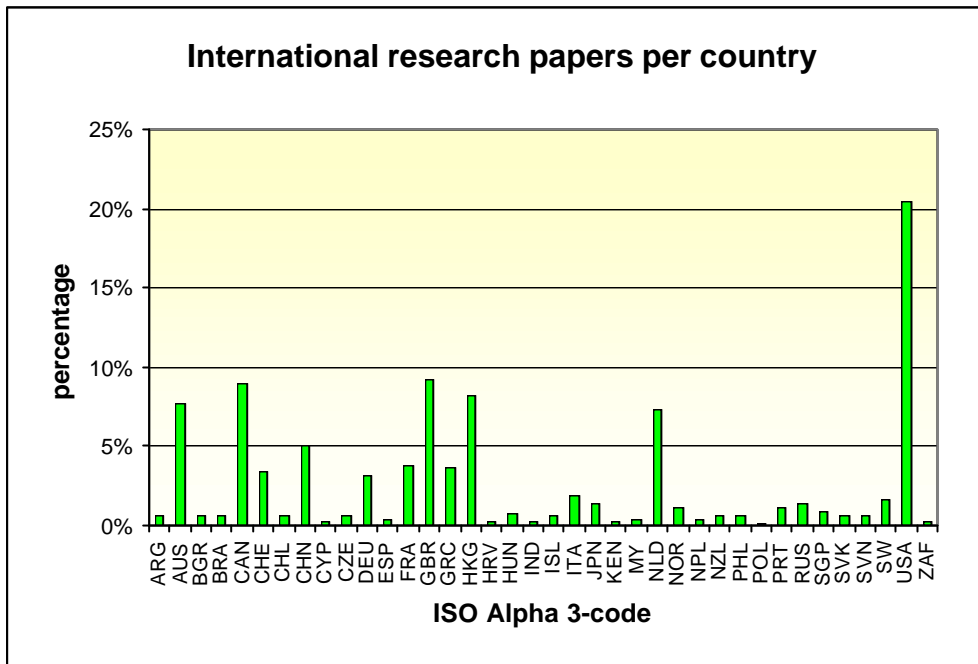


Figure 13 International research papers according to origin of authors per country in IJGIS between 1987 and 2004

In Figure 14 the development of only internationally published papers is displayed over the years. The research was investigated from 1987 till 2004, but the international cooperation between various countries had begun since 1990. In general, the increasing trend in international cooperation excluding country specification was investigated. The year 1997 is an important one for the international cooperation. This has been influenced by 10th anniversary of IJGIS. The highest percentage from all international papers was present in years 1999 and 2001.

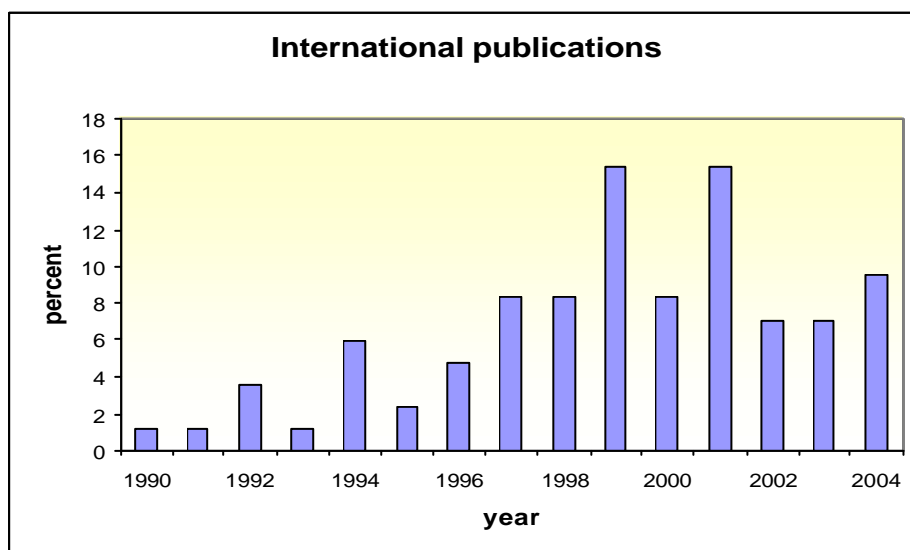


Figure 14 International research papers according to origin of author(s) over time per country in IJGIS between 1987 and 2004

3.3 Content of research papers

In this paragraph I will concentrate the attention on following questions:

What are the research papers about?

What is in the research papers and what trend will be explored?

3.3.1 Main focus

In the following table, the main focus over time according to IJGIS is shown. At the beginning of IJGIS, most papers were published regarding to application through technology to research. Already from 4th year of publishing IJGIS the research has been dominating focus for publishing the papers. Technology has fluctuating trend but it keeps far behind the research. I can conclude that in the papers the development of GIS considers content of Main focus from streaming from application through technology to research. The highest amount of the articles was dedicated to research.

Table 8 Main focus of research papers in IJGIS between 1987 and 2004

Main focus in %			
Year	Research	Technology	Application
1987	30.43	28.26	41.30
1988	48.08	32.69	19.23
1989	30.43	34.78	34.78
1990	46.67	43.33	10.00
1991	44.83	34.48	20.69
1992	62.12	34.85	3.03
1993	55.88	44.12	0.00
1994	66.67	26.67	6.67
1995	65.71	30.00	4.29
1996	65.69	31.37	2.94
1997	69.74	27.63	2.63
1998	76.14	19.32	4.55
1999	67.07	30.49	2.44
2000	86.05	3.49	10.47
2001	64.63	26.83	8.54
2002	78.05	19.51	2.44
2003	61.11	33.33	5.56
2004	79.73	16.22	4.05

3.3.2 Application field

Application and Earth sciences

Geo-information as a science can be applied to many fields. The application fields were chosen according to ISI's Web of Science. The most significant of application fields over time are Earth sciences, Economic and business, Social sciences and Environment and ecology. Regarding to Figure 15 and Appendix B the Earth Sciences (Figure 16) have in general highest percentage with increasing trend in the last six years.

Environment and ecology, natural hazards and disasters have a decreasing character coming to presence (2004). The policy making is the strongest in 1987 (13.04%) and 1988 (19.23) due to setting up policy for implementing GIS as a new term.

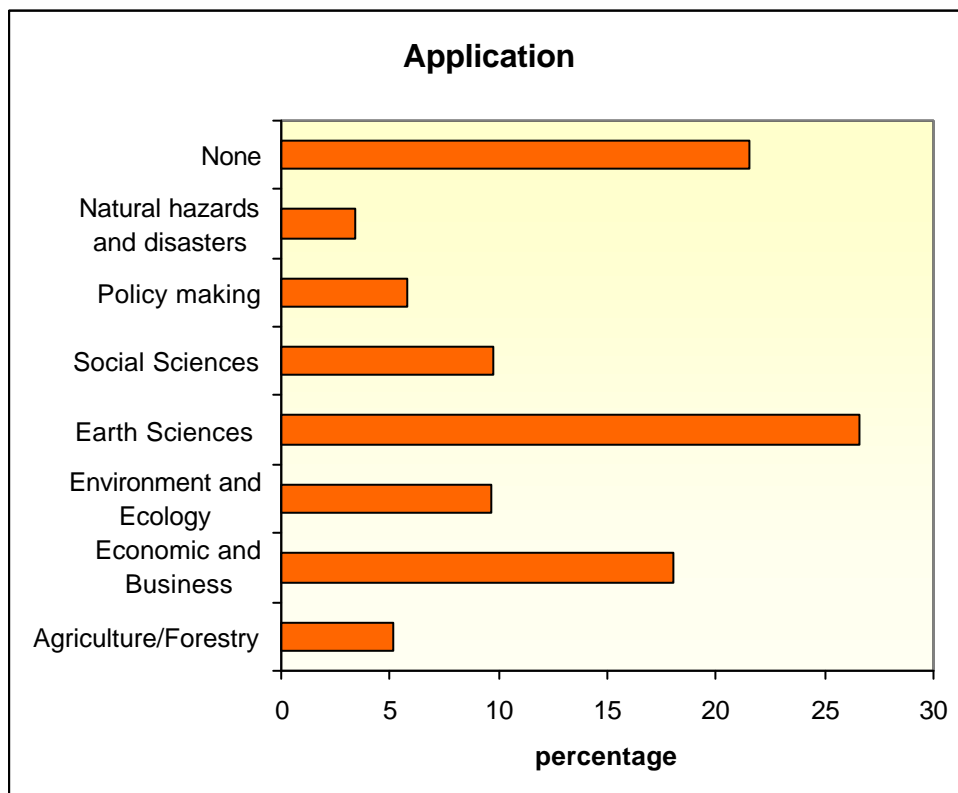


Figure 15 Overall field of application in IJGIS between 1987 and 2004

3.3.3 Earth Sciences

In this section the main attention will be paid to different trends within Earth science. Within Earth sciences landuse, soil science, geology, and spatial planning and landscape architecture (see Figure 15) are dominating over

research period. Significant growth from year 1987 till 2004, especially in economics and business, and also in social sciences is shown.

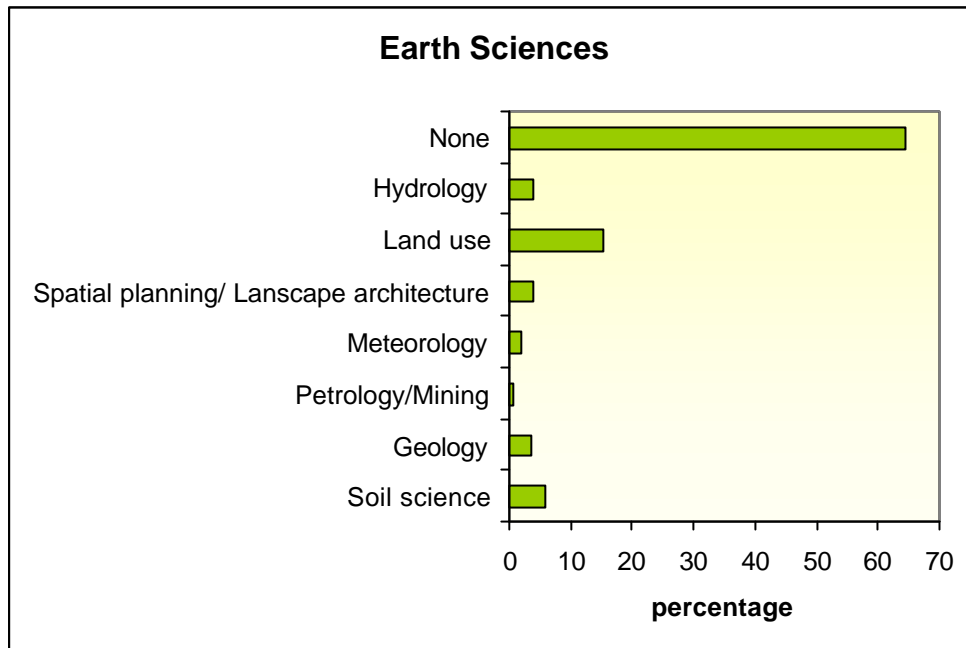


Figure 16 Overall Earth Sciences during in IJGIS between 1987 and 2004

3.3.4 “The five bullets” (NSF) solicitation

In the Figure 17, “The five bullets” according to NSF solicitation are presented. Generally, the majority of research papers published in IJGIS is dedicated to spatial analysis at first place with approximately 32 percent. Next are spatial relations and database structures with about 23 percent and visualization with 16 percent follows. The last ones are social, economic and institutional issues (15%) and Artificial intelligence and expert systems (12%). Only 2 percent of this group did not belong to any of mentioned groups. Due to the most papers dedicated to the bullet “Spatial analysis and spatial statistics”, more detailed description follows in Figure 18. Spatial analysis and spatial statistics have been one of the most studied bullets from 1987 to 2004. At the beginning of the research period, spatial analysis and spatial statistics had constantly growing trend in the papers over years. Even in year 2000 reached the highest number of papers and stay also dominant in the research until the end of research period.

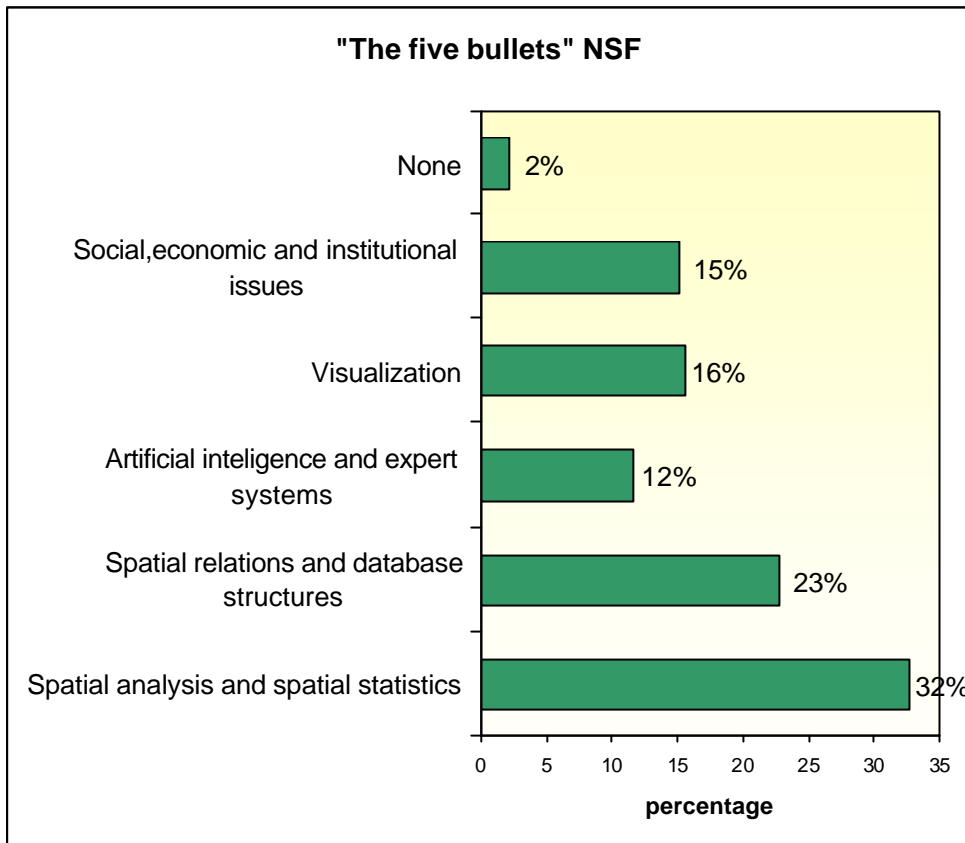


Figure 17 Summary overview "The five bullets" (NSF) between 1987 and 2004 in IJGIS

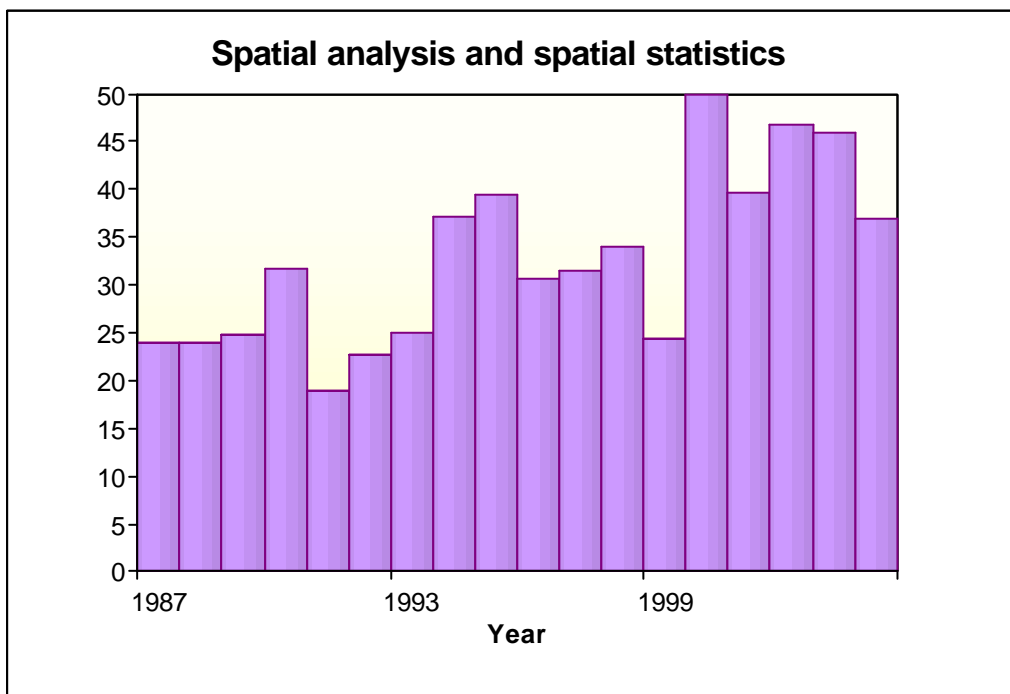


Figure 18 "Spatial analysis and spatial statistics" between 1987 and 2004 in IJGIS

The spatial relations and database structures between 1987 and 1990 have the growing character in papers in Figure 19. The largest number of papers

within this issue is published in year 1989. Following this until 1995, the number of papers has decreased. Later fluctuating till decreasing amount of papers from year 2002 to 2004 is present.

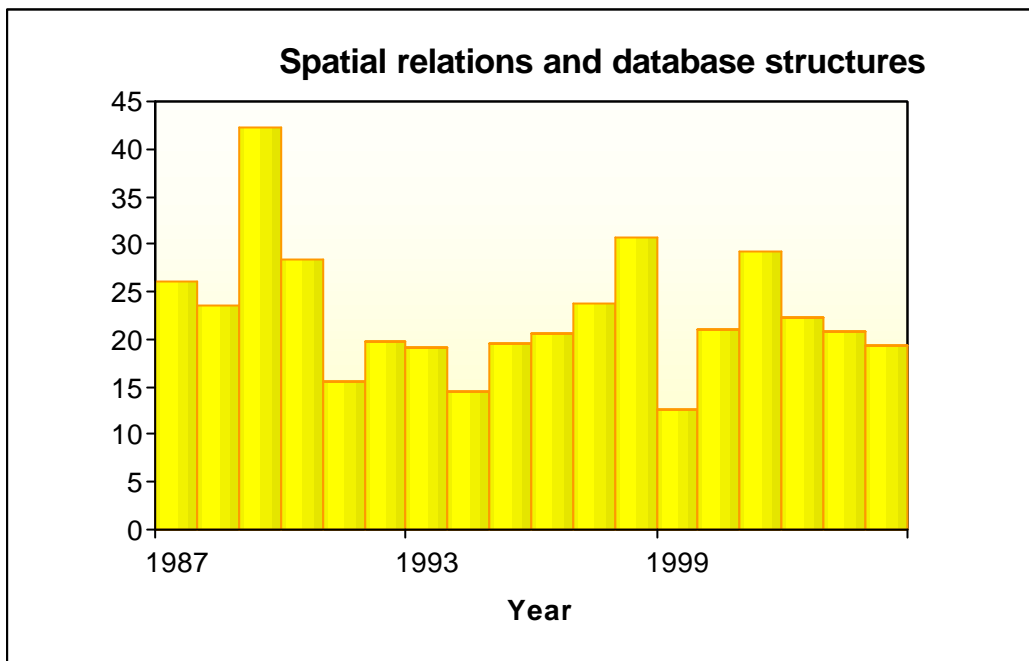


Figure 19 "Spatial relations and database structures" between 1987 and 2004 in IJGIS

Further, in the following figure I will pay a small attention to visualization. In 1999 due to special issue 'Visualization for exploration of spatial data' the highest number of articles is assigned to this issue. Just one year later the percentage for this field decreases but is still improving in quantity till present (2004). I will also shortly describe social, economic and institutional issues which were present more in earlier period. This issue has its expanding time in years 1991 and 1992. Since then there has been a decreasing trend. In year 1998 (volume 12 issue 4) and 2000 (volume 14 issue 8) were the special issues published. This was the reason of increasing number of paper within this bullet. Artificial intelligence and expert systems are constant over time in quantity of papers published.

3.3.5 GI Issues

In the following paragraph, I will describe overall development of GI Issues, and then I will briefly describe selected issues from all eighteen GI issues. This selection will be done with more respect to main issues and then to one of the GI latest issue. In this section there are potential GI issues which could

be grouped according to close relation between them or one issue being a part of the other. After joining the few issues I will come up with these results. In Figure 20, an overview of GI issues for whole research period (1987-2004) is summarized. Firstly, I want to list just the most present issues with its percentage number from the most mentioned issues to the issues with lowest value. In general, the most represented in research papers are issues about spatial modelling (15.8%), GIS (12.5%), geo-computation (11.3%), spatial data quality (8.3%), geo-database (7.1%), data management (6.5%), spatial statistics (5.6%), various (5.5%) and cartography (5.3%). Still new issues in Geo-information science as Spatial Data Infrastructure and ontology need to be explored and developed in future. Spatial data infrastructure issue was for first time mentioned in IJGIS in year 1999, but introduced in GIS as a new issue in 1999 This Geo-information issues has a growing tendency from 1999 to 2004.

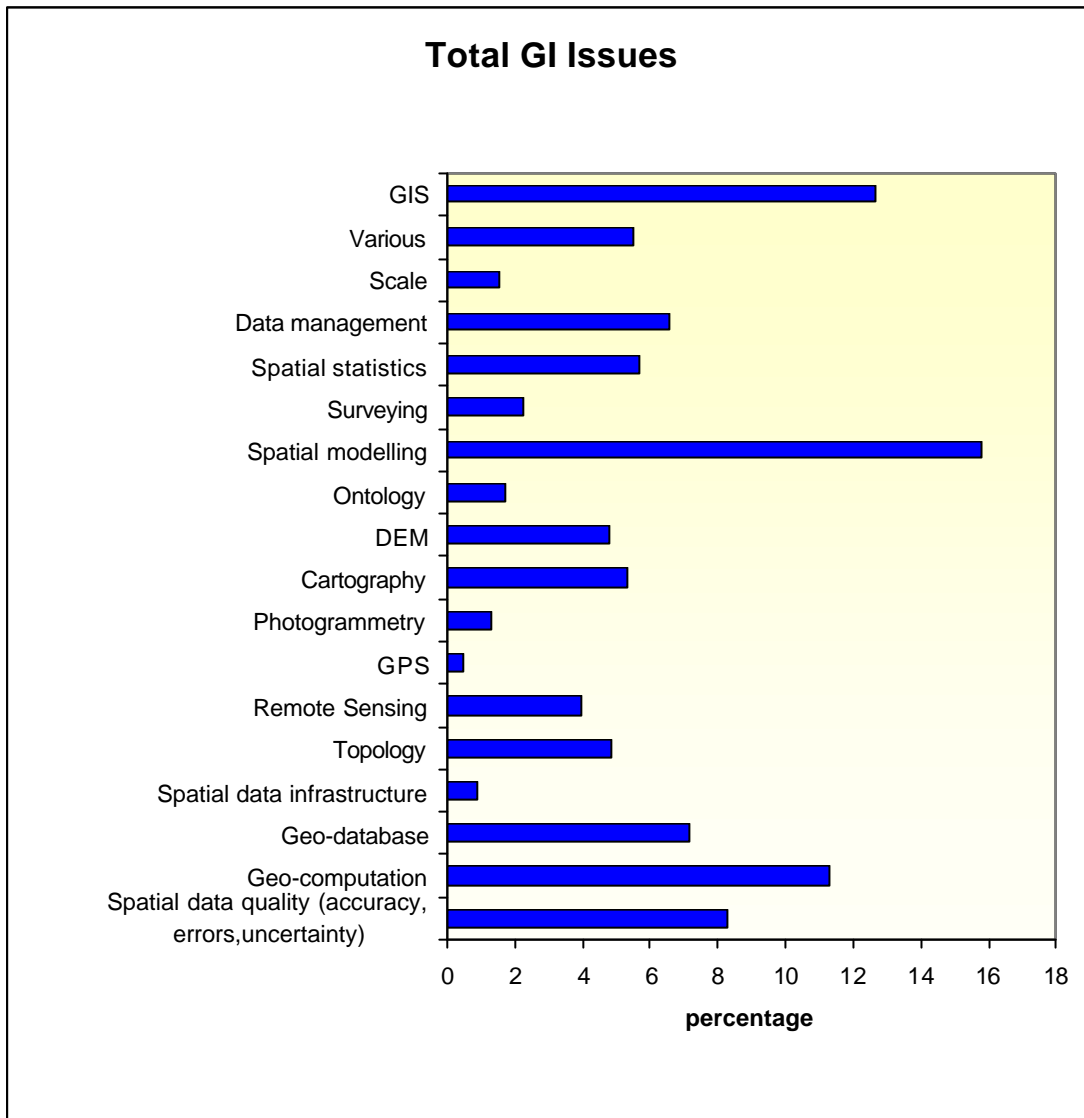


Figure 20 Summary overview of “GI issues” between 1987 and 2004 in IJGIS

Further in this chapter one of most occurred issue will be described. In Figure 21, the increasing trend for spatial modelling over the years is present. To spatial modelling as already mentioned above was assigned 15.8% in total. This is the highest number within this group. Not only enhance is important but also the stability in the development of this issue for last 6 years (1999-2004).

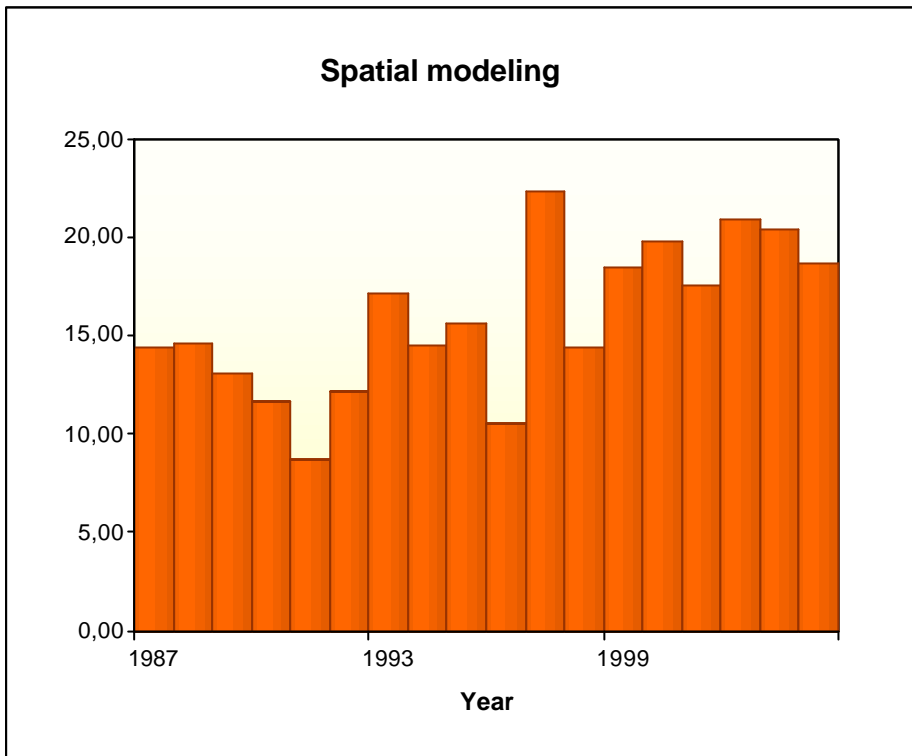


Figure 21 Spatial modelling in IJGIS between 1987 and 2004

Once, data management and geo-database were grouped and shown in figure 22 I can discover declining trend.

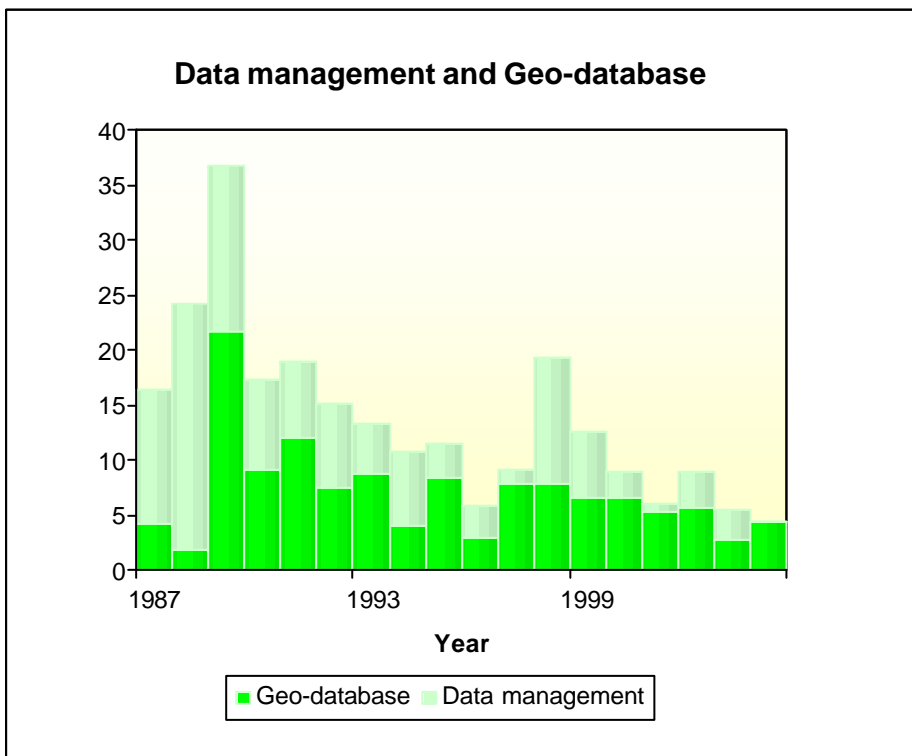


Figure 22 Data management and Geo-database between 1987 and 2004 in IJGIS

Lately the high attention is being concentrated on data quality, errors, and uncertainty. Fluctuating with slight increase is present (see Figure 23). Some peaks are obvious in year 1997 and also later in year 2000 and 2002. These two last peaks are present due to the special issues published.

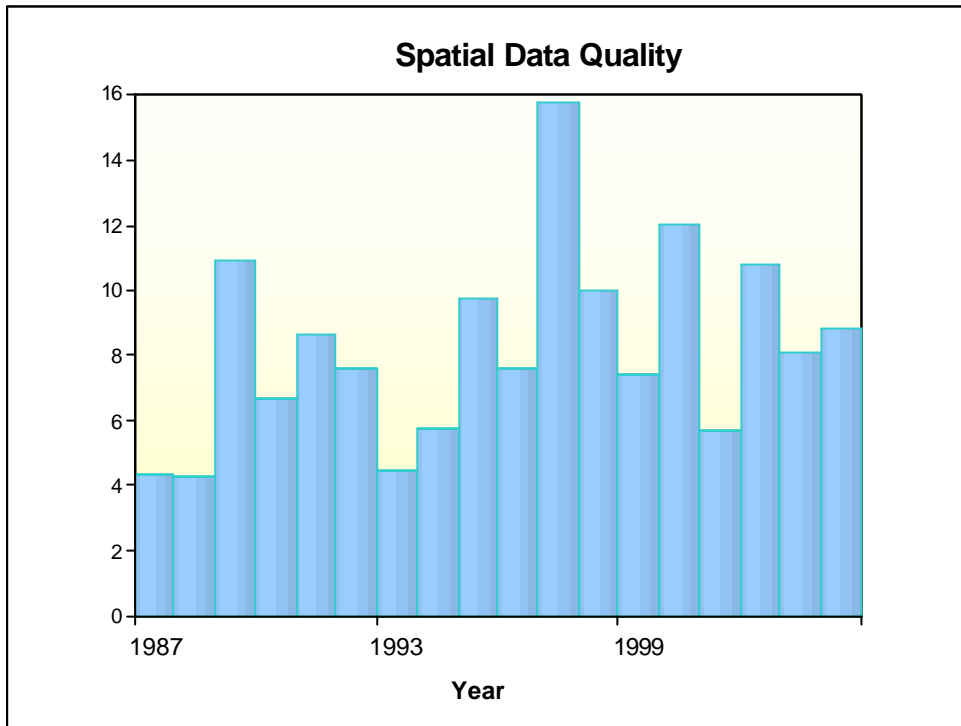


Figure 23 Spatial data quality in IJGIS between 1987 and 2004

Remote sensing and Photogrammetry as a science have own ups and downs during whole research period. As I can investigate in figure 24 last three years decrease of writing about spatial data quality is present. Fluctuating trend.

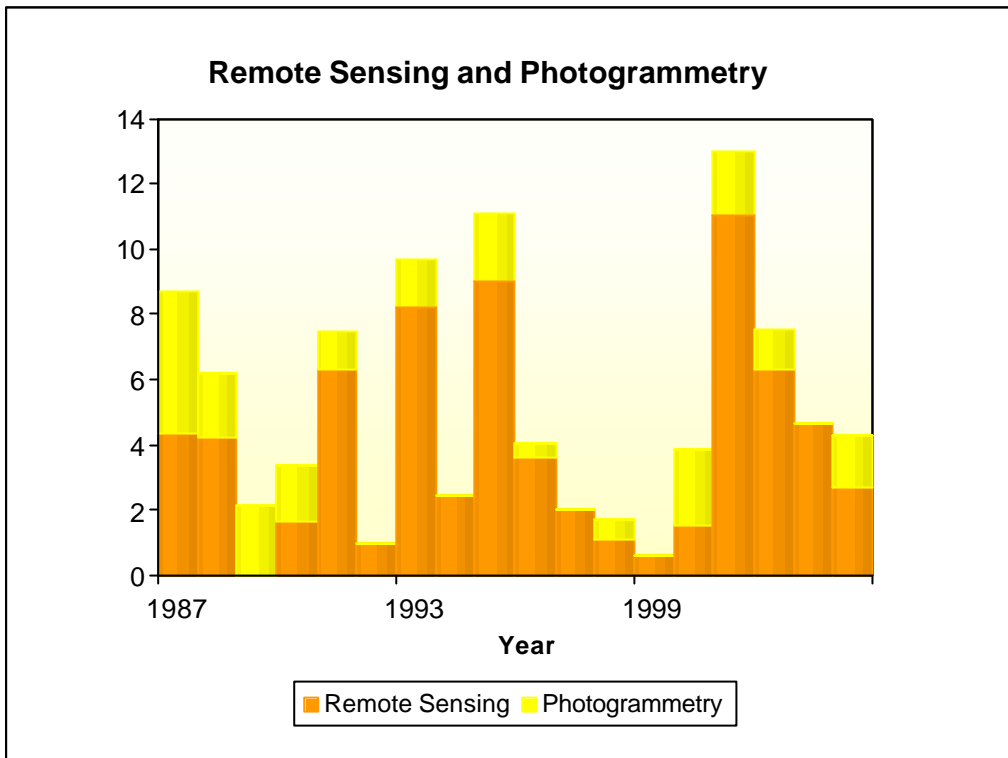


Figure 24 Remote Sensing and photogrammetry in IJGIS between 1987 and 2004

Spatial Data Infrastructure as a relatively new topic in GIS is not completely explored yet. A proof of this is shown in figure 25. First articles dedicated to this GI issue were published in year 1999. There is relatively stable number of papers being published until the end of research period.

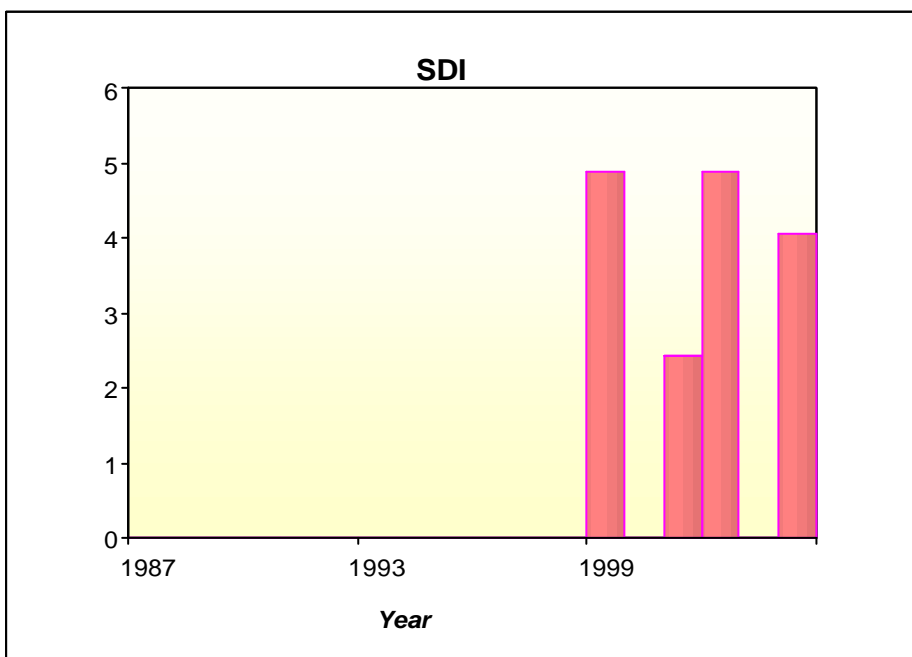


Figure 25 Spatial data Infrastructure in IJGIS between 1987 and 2004

This issue was the one of the last ones considering the number of papers. I hope it is not the last new issues to discover in development of GIS in IJGIS.

4 Conclusions and discussion

In this final chapter the conclusions as a result of gained and gathered information about Development of GIS in IJGIS will be derived. In this final paragraph I will conclude in the same order as in the chapter 3 the results of GI development from a broad scope to specific issues.

In general, the amount of authors, pages with amount of volumes increases. The number of papers in last two years (2003, 2004) is decreasing. In IJGIS the year 1996 is one of the most productive in amount of authors, papers and pages published. In this same year European authors are publishing the most articles.

Regarding to chapters 3.2.1 and 3.2.2, it is interesting to mention the bigger difference between Europe and North America (about 6 % is the European origin of research in ahead than in North America where else in origin of author is the difference smaller 4.5%). What is also interesting to see is the switch between Asia and Oceania by means that in Asia was more research applied than in Oceania. This should be opposite of what I could expect regarding to origin of authors. The opposite is the truth. This can be caused by the smallest number of countries in Oceania than in Asia. The same reason is present in case of Africa and South and Central America. Elsewhere in South and Central America the communication problem considering different language used in countries could be another factor.

According to origin of the research the best publishers of research articles are the Europeans and researchers from North America. Dominant countries within Europe are considered British and Dutch authors and from North America authors from USA. In IJGIS is a strong dominance in GI research by "Anglo Saxon" Countries within Europe and higher dominance of USA in North America.

Last 5 years (2000 – 2004), the Asian authors are publishing more research papers in IJGIS. Between years 2001 and 2004 the international cooperation in writing research papers especially in Hong Kong is increasing.

The international cooperation started from 1990 and is expanding over the years. More countries are involved in publishing articles from eight countries in 1987 to 22 countries in 2004. Considering the origin of authors and cooperation between different countries, it is easy to conclude that the cooperation between countries reached highest point in years 1999 and also in 2001. There is a tendency in the future to expand the cooperation and also keep more countries active in publishing scientific papers.

During research was also important to experience connections between the results and knowing the IJGIS journal with its history, structure and overall overview. Special issues are attracting and challenging the authors to take a part on specific and specialized GI issues. I can consider the special issues as positive in the development of GIS.

The strong emphasis are on application of research then straight to technology and as last to research over time from 1987 till 2004.

Many of GI issues stay relatively constant such as Spatial modelling over the time. Few of them are established during the publicity such as Spatial data Infrastructure and some are unstable having its ups and downs.

I expect the rapid growth of number of research papers published in volume 20. Currently (2006), it is already known that number of issues has increased to ten. I expect that Geo-Information as a science in its development will not only bring new GI issues into its field but also more cooperation between the different nations.

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Appendix A

ISO Alpha-3 country codes with country names

Countries or areas, codes and abbreviations according to methods and classifications of Statistics division of the UN (United Nations)

<http://unstats.un.org/unsd/methods/m49/m49alpha.htm>

(Listing in alphabetical order) a/

Numerical code	Country or area name	ISO ALPHA-3 country code
004	Afghanistan	AFG
248	Åland Islands	ALA
008	Albania	ALB
012	Algeria	DZA
016	American Samoa	ASM
020	Andorra	AND
024	Angola	AGO
660	Anguilla	AIA
028	Antigua and Barbuda	ATG
032	Argentina	ARG
051	Armenia	ARM
533	Aruba	ABW
036	Australia	AUS
040	Austria	AUT
031	Azerbaijan	AZE
044	Bahamas	BHS
048	Bahrain	BHR
050	Bangladesh	BGD
052	Barbados	BRB
112	Belarus	BLR
056	Belgium	BEL
084	Belize	BLZ
204	Benin	BEN
060	Bermuda	BMU
064	Bhutan	BTN
068	Bolivia	BOL
070	Bosnia and Herzegovina	BIH
072	Botswana	BWA
076	Brazil	BRA
092	British Virgin Islands	VGB
096	Brunei Darussalam	BRN
100	Bulgaria	BGR
854	Burkina Faso	BFA
108	Burundi	BDI
116	Cambodia	KHM
120	Cameroon	CMR
124	Canada	CAN
132	Cape Verde	CPV
136	Cayman Islands	CYM
140	Central African Republic	CAF
148	Chad	TCD
830	Channel Islands	
152	Chile	CHL
156	China	CHN

Numerical code	Country or area name	ISO ALPHA-3 country code
344	Hong Kong Special Administrative Region of China	HKG
446	Macao Special Administrative Region of China	MAC
170	Colombia	COL
174	Comoros	COM
178	Congo	COG
184	Cook Islands	COK
188	Costa Rica	CRI
384	Côte d'Ivoire	CIV
191	Croatia	HRV
192	Cuba	CUB
196	Cyprus	CYP
203	Czech Republic	CZE
408	Democratic People's Republic of Korea	PRK
180	Democratic Republic of the Congo	COD
208	Denmark	DNK
262	Djibouti	DJI
212	Dominica	DMA
214	Dominican Republic	DOM
218	Ecuador	ECU
818	Egypt	EGY
222	El Salvador	SLV
226	Equatorial Guinea	GNQ
232	Eritrea	ERI
233	Estonia	EST
231	Ethiopia	ETH
234	Faeroe Islands	FRO
238	Falkland Islands (Malvinas)	FLK
242	Fiji	FJI
246	Finland	FIN
250	France	FRA
254	French Guiana	GUF
258	French Polynesia	PYF
266	Gabon	GAB
270	Gambia	GMB
268	Georgia	GEO
276	Germany	DEU
288	Ghana	GHA
292	Gibraltar	GIB
300	Greece	GRC
304	Greenland	GRL
308	Grenada	GRD
312	Guadeloupe	GLP
316	Guam	GUM
320	Guatemala	GTM
324	Guinea	GIN
624	Guinea-Bissau	GNB
328	Guyana	GUY
332	Haiti	HTI
336	Holy See	VAT
340	Honduras	HND
348	Hungary	HUN
352	Iceland	ISL
356	India	IND
360	Indonesia	IDN

Numerical code	Country or area name	ISO ALPHA-3 country code
364	Iran (Islamic Republic of)	IRN
368	Iraq	IRQ
372	Ireland	IRL
833	Isle of Man	
376	Israel	ISR
380	Italy	ITA
388	Jamaica	JAM
392	Japan	JPN
400	Jordan	JOR
398	Kazakhstan	KAZ
404	Kenya	KEN
296	Kiribati	KIR
414	Kuwait	KWT
417	Kyrgyzstan	KGZ
418	Lao People's Democratic Republic	LAO
428	Latvia	LVA
422	Lebanon	LBN
426	Lesotho	LSO
430	Liberia	LBR
434	Libyan Arab Jamahiriya	LBY
438	Liechtenstein	LIE
440	Lithuania	LTU
442	Luxembourg	LUX
450	Madagascar	MDG
454	Malawi	MWI
458	Malaysia	MYS
462	Maldives	MDV
466	Mali	MLI
470	Malta	MLT
584	Marshall Islands	MHL
474	Martinique	MTQ
478	Mauritania	MRT
480	Mauritius	MUS
175	Mayotte	MYT
484	Mexico	MEX
583	Micronesia (Federated States of)	FSM
492	Monaco	MCO
496	Mongolia	MNG
500	Montserrat	MSR
504	Morocco	MAR
508	Mozambique	MOZ
104	Myanmar	MMR
516	Namibia	NAM
520	Nauru	NRU
524	Nepal	NPL
528	Netherlands	NLD
530	Netherlands Antilles	ANT
540	New Caledonia	NCL
554	New Zealand	NZL
558	Nicaragua	NIC
562	Niger	NER
566	Nigeria	NGA
570	Niue	NIU
574	Norfolk Island	NFK

Numerical code	Country or area name	ISO ALPHA-3 country code
580	Northern Mariana Islands	MNP
578	Norway	NOR
275	Occupied Palestinian Territory	PSE
512	Oman	OMN
586	Pakistan	PAK
585	Palau	PLW
591	Panama	PAN
598	Papua New Guinea	PNG
600	Paraguay	PRY
604	Peru	PER
608	Philippines	PHL
612	Pitcairn	PCN
616	Poland	POL
620	Portugal	PRT
630	Puerto Rico	PRI
634	Qatar	QAT
410	Republic of Korea	KOR
498	Republic of Moldova	MDA
638	Réunion	REU
642	Romania	ROU
643	Russian Federation	RUS
646	Rwanda	RWA
654	Saint Helena	SHN
659	Saint Kitts and Nevis	KNA
662	Saint Lucia	LCA
666	Saint Pierre and Miquelon	SPM
670	Saint Vincent and the Grenadines	VCT
882	Samoa	WSM
674	San Marino	SMR
678	Sao Tome and Principe	STP
682	Saudi Arabia	SAU
686	Senegal	SEN
891	Serbia and Montenegro	SCG
690	Seychelles	SYC
694	Sierra Leone	SLE
702	Singapore	SGP
703	Slovakia	SVK
705	Slovenia	SVN
090	Solomon Islands	SLB
706	Somalia	SOM
710	South Africa	ZAF
724	Spain	ESP
144	Sri Lanka	LKA
736	Sudan	SDN
740	Suriname	SUR
744	Svalbard and Jan Mayen Islands	SJM
748	Swaziland	SWZ
752	Sweden	SWE
756	Switzerland	CHE
760	Syrian Arab Republic	SYR
762	Tajikistan	TJK
764	Thailand	THA
807	The former Yugoslav Republic of Macedonia	MKD
626	Timor-Leste	TLS

Numerical code	Country or area name	ISO ALPHA-3 country code
768	Togo	TGO
772	Tokelau	TKL
776	Tonga	TON
780	Trinidad and Tobago	TTO
788	Tunisia	TUN
792	Turkey	TUR
795	Turkmenistan	TKM
796	Turks and Caicos Islands	TCA
798	Tuvalu	TUV
800	Uganda	UGA
804	Ukraine	UKR
784	United Arab Emirates	ARE
826	United Kingdom of Great Britain and Northern Ireland	GBR
834	United Republic of Tanzania	TZA
840	United States of America	USA
850	United States Virgin Islands	VIR
858	Uruguay	URY
860	Uzbekistan	UZB
548	Vanuatu	VUT
862	Venezuela	VEN
704	Viet Nam	VNM
876	Wallis and Futuna Islands	WLF
732	Western Sahara	ESH
887	Yemen	YEM
894	Zambia	ZMB
716	Zimbabwe	ZWE

a/ The designations employed and the presentation of country or area names in this list do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The user of any particular dataset should consult the dataset documentation to determine the exact coverage of statistics for the country or area entities in the dataset. Various datasets may or may not include coverage of outlying and overseas areas, depending on the type of data and source.

Appendix B

National research papers according to origin of the authors in IJGIS between 1987 and 2004 is in the table presented

Count	Country code	National (%)
1	AUS	8%
2	AUT	1%
3	BEL	1%
4	CAN	6%
5	DEU	2%
6	ESP	1%
7	FRA	2%
8	GBR	21%
9	GRC	1%
10	HKG	3%
11	CHE	1%
12	CHN	2%
13	ITA	2%
14	JPN	1%
15	NLD	7%
16	NOR	1%
17	NZL	2%
18	RUS	1%
19	SGP	1%
20	SWE	1%
21	USA	32%

International research papers according to geographic origin of the authors in IJGIS between 1987 and 2004 is in the table presented

Count	Country code	International (%)
1	ARG	0,6%
2	AUS	7,7%
3	BGR	0,6%
4	BRA	0,6%
5	CAN	9,0%
6	CHE	3,4%
7	CHL	0,6%
8	CHN	5,1%
9	CYP	0,2%
10	CZE	0,6%
11	DEU	3,2%
12	ESP	0,4%
13	FRA	3,8%
14	GBR	9,2%
15	GRC	3,7%
16	HKG	8,2%
17	HRV	0,3%
18	HUN	0,8%
19	IND	0,3%
20	ISL	0,6%
21	ITA	1,9%
22	JPN	1,4%
23	KEN	0,3%
24	MYS	0,4%
25	NLD	7,3%
26	NOR	1,2%
27	NPL	0,4%
28	NZL	0,6%
29	PHL	0,6%
30	POL	0,1%
31	PRT	1,2%
32	RUS	1,4%
33	SGP	0,9%
34	SVK	0,6%
35	SVN	0,6%
36	SWE	1,6%
37	USA	20,4%
38	ZAF	0,3%

Countries with international or intercontinental cooperation between 1987(1990) and 2004

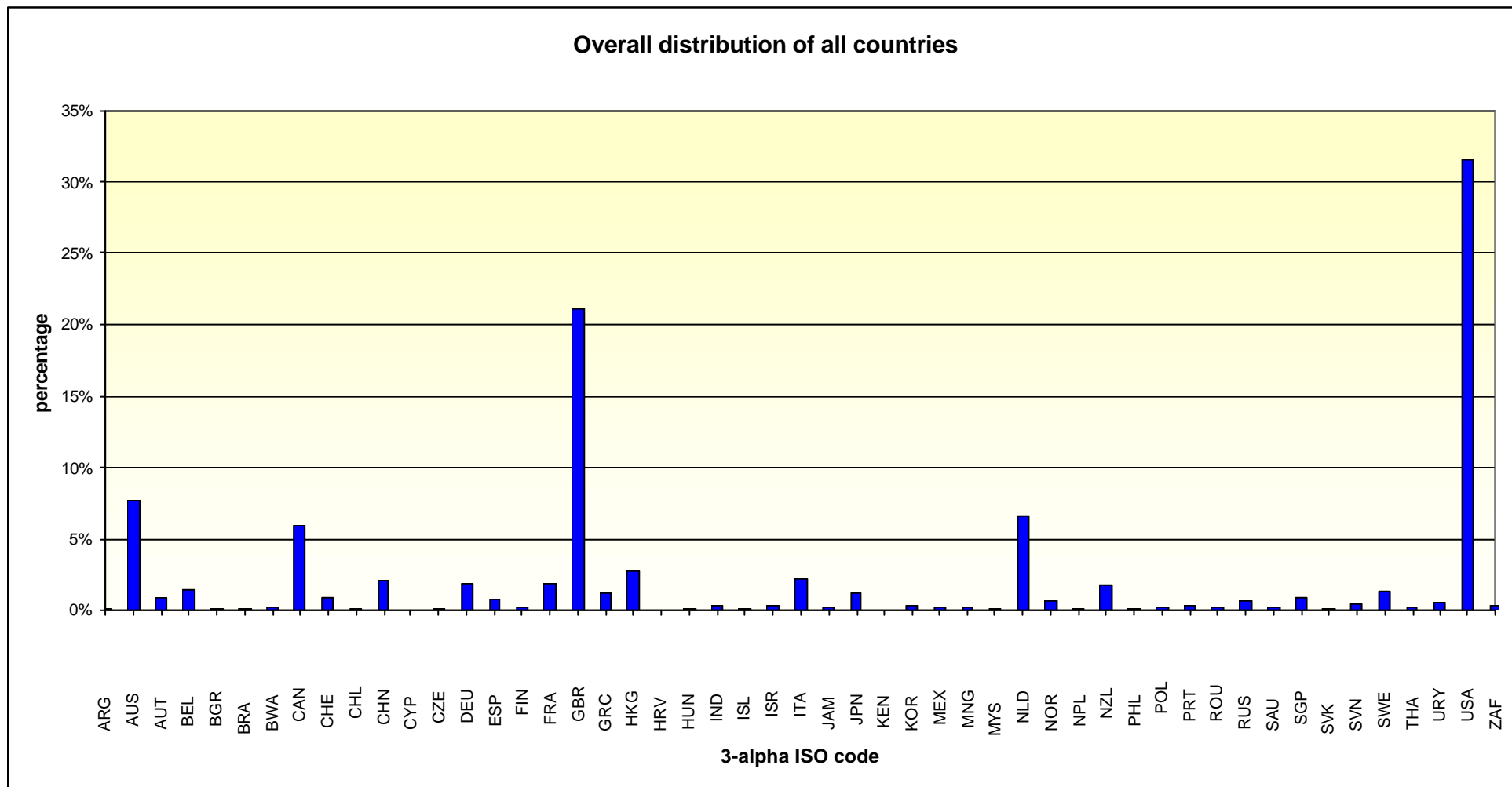
Country ISO Alpha-3 code	Year															Total
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
ARG	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.6%
AUS	.0%	.0%	.0%	.0%	.0%	.0%	.0%	1.8%	1.1%	1.9%	1.2%	.6%	.0%	.6%	.6%	7.7%
BGR	.0%	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%
BRA	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.6%
CAN	.6%	.0%	.0%	.0%	.4%	.8%	.4%	.3%	.6%	1.3%	.6%	2.6%	.8%	.0%	.6%	9.0%
CHE	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.0%	.8%	.4%	.0%	.8%	.0%	.0%	.8%	3.4%
CHL	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.6%
CHN	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	1.2%	.0%	1.2%	.6%	.9%	.6%	5.1%
CYP	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.2%	.0%	.0%	.0%	.0%	.2%
CZE	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.6%
DEU	.0%	.0%	.0%	.0%	.0%	.4%	.0%	.3%	.0%	.6%	.0%	1.2%	.3%	.4%	.0%	3.2%
ESP	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.4%	.0%	.0%	.0%	.4%
FRA	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.4%	1.6%	.8%	.3%	.0%	.0%	.7%	3.8%
GBR	.0%	.6%	1.7%	.0%	.4%	.0%	1.4%	.6%	.4%	.6%	.0%	2.5%	.6%	.4%	.0%	9.2%
GRC	.0%	.0%	.0%	.0%	.4%	.0%	.0%	1.5%	.0%	1.2%	.0%	.0%	.6%	.0%	.0%	3.7%
HKG	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.3%	.6%	1.6%	.0%	2.7%	1.2%	.6%	1.2%	8.2%
HRV	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.3%	.3%
HUN	.0%	.0%	.0%	.0%	.0%	.0%	.8%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.8%
IND	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.3%	.0%	.0%	.0%	.0%	.0%	.3%
ISL	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.6%
ITA	.0%	.0%	.0%	.0%	1.1%	.0%	.4%	.0%	.4%	.0%	.0%	.0%	.0%	.0%	.0%	1.9%
JPN	.0%	.0%	.0%	.0%	.8%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	1.4%
KEN	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.3%	.0%	.0%	.3%
MYS	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.4%	.0%	.0%	.0%	.0%	.0%	.0%	.4%
NLD	.0%	.0%	.6%	.0%	.4%	.8%	.0%	.5%	.0%	.0%	.0%	1.8%	.9%	.0%	2.4%	7.3%

Country ISO Alpha-3 code	Year															Total
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
NOR	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.6%	.0%	.0%	.0%	.0%	1.2%
NPL	.0%	.0%	.0%	.0%	.0%	.4%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.4%
NZL	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.6%
PHL	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.6%
POL	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.1%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.1%
PRT	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	1.2%
RUS	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.8%	.0%	.6%	.0%	.0%	1.4%
SGP	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.9%	.0%	.0%	.0%	.0%	.0%	.0%	.9%
SVK	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%
SVN	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.6%
SWE	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.6%	.0%	.4%	.0%	.6%	.0%	1.6%
USA	.6%	.6%	.7%	.6%	1.9%	.0%	1.2%	2.4%	2.2%	3.6%	1.7%	1.0%	1.0%	1.9%	1.2%	20.4%
ZAF	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.3%	.0%	.0%	.3%
Total	1.2%	1.2%	3.6%	1.2%	5.9%	2.4%	4.8%	8.3%	8.3%	15.5%	8.3%	15.5%	7.1%	7.1%	9.5%	100.0%

Overall distribution of countries for research period 1987-2004

ISO Alpha-3 country code	Total
ARG	0.08%
AUS	7.64%
AUT	0.79%
BEL	1.42%
BGR	0.08%
BRA	0.08%
BWA	0.16%
CAN	5.91%
CHE	0.92%
CHL	0.08%
CHN	2.09%
CYP	0.03%
CZE	0.08%
DEU	1.84%
ESP	0.68%
FIN	0.16%
FRA	1.92%
GBR	21.04%
GRC	1.27%
HKG	2.66%
HRV	0.04%
HUN	0.11%
IND	0.35%
ISL	0.08%
ISR	0.31%
ITA	2.14%
JAM	0.16%
JPN	1.29%
KEN	0.04%
KOR	0.31%
MEX	0.16%
MNG	0.16%
MYS	0.05%
NLD	6.63%
NOR	0.63%
NPL	0.05%
NZL	1.81%
PHL	0.08%
POL	0.17%
PRT	0.31%
ROU	0.16%
RUS	0.66%
SAU	0.16%
SGP	0.91%
SVK	0.08%
SVN	0.39%
SWE	1.31%
THA	0.16%
URY	0.47%
USA	31.54%
ZAF	0.35%
Grand Total	100.00%

Summary of the origin of author per country between years 1987 and 2004



Appendix C

Overall results according to content attributes

Group	Variable	Percentage	
Main focus	Research	61,06	
	Technology	28,74	
	Application	10,20	
Type of the research	Application	39,43	
	Methodological/Conceptual	44,97	
	Review	15,60	
Spatial data handling	Data capture	7,25	
	Data structuring	21,40	
	Data analysis	34,01	
	Data display	19,85	
	None	17,48	
Spatial dimension (SDI)	Local level	36,29	
	State level	5,26	
	National level	7,96	
	Regional level	3,25	
	Global level	2,52	
	None	44,72	
Application	Agriculture/Forestry	5,15	
	Economics and Business	18,07	
	Environment and Ecology	9,68	
	Earth Sciences	26,62	
	Social Sciences	9,79	
	Policy making	5,79	
	Natural hazards and disasters	3,41	
	None	21,50	
	Earth Sciences	Soil science	6,00
		Geology	3,62
Petrology/ Mining		0,74	
Meteorology		1,84	
Spatial planning/ Landscape architecture		3,94	
Land use		15,40	
Hydrology		4,06	
None		64,41	
"The five bullets" in NSF solicitation	Spatial analysis and spatial statistics	32,65	
	Spatial relations and database structures	22,71	
	Artificial intelligence and expert systems	11,72	
	Visualization	15,51	
	Social, economic and institutional issues	15,19	
	None	2,22	
Urban/Rural	Urban	25,03	
	Rural	29,73	
	Both (yes/no)	0,19	
	None	45,05	
GIS Components	Software	29,01	

Group	Variable	Percentage
(organizational geo-wares)		
	Hardware	5,79
	Humanware	4,49
	Dataware	43,23
	Orgware	12,82
	None	4,66
Space and time	Space	70,96
	Time	29,04
	Both (yes/no)	0,00
	None	0,00
GIS Issues	Spatial data quality (accuracy, errors, uncertainty)	8,25
	Geo-computation	11,30
	Geo-database	7,13
	Spatial data infrastructure	0,90
	Topology	4,87
	Remote Sensing	3,93
	GPS	0,46
	Photogrammetry	1,28
	Cartography	5,32
	DEM	4,83
	Ontology	1,75
	Spatial modeling	15,81
	Surveying	2,27
	Spatial statistics	5,70
	Data management	6,53
	Scale	1,50
	Various	5,52
	GIS	12,65

Appendix D

Geographical distribution according to origin of author in IJGIS between 1987 and 2004

