Geographic Information Systems in Information Systems Research Review and Research Prospects

Jennifer Priefer
Paderborn University
jennifer.priefer@uni-paderborn.de

Abstract

Since historical times, cartographic maps have revealed spatial relations and enabled decisions and processes. Geographic Information Systems (GIS) allow for acquisition, management, analysis, and presentation of geospatial objects. With free geospatial data becoming available through open data policies and an increasing amount of digitally connected objects in the Internet of Things (IoT), GIS are becoming indispensable to Information Systems (IS) research. However, the consideration and relevance of GIS has only been investigated rarely. We examine, how and in which fields of application GIS have been studied in the IS literature and elicit the importance of GIS regarding their design and usage. A systematic literature review leads us to develop four research propositions. Our results indicate that GIS are still an undeservedly underrepresented discipline in IS and should be more theorized, put center-stage in design-oriented research, and considered for creating superior value co-creation in service systems.

Keywords: GIS, Geographic Information System, IS, Information Systems Research, Literature Review.

1. Introduction

Since early historical times, cartographic maps have played an important role for mankind. Whether for navigation on sea or land——maps have always constituted an invaluable tool and brought considerable benefits to their owners, especially regarding their use for spatial analytics. As early as 1854, Dr. John Snow collected data on cholera deaths in London. By visualizing his findings on a map using spatial analytics, he revealed an up to then unknown spatial relation between cholera outbreaks and wells, from which the surrounding population drew their drinking water. Only through spatial analysis of the data the cause of the cholera deaths could be directly connected to drinking water contaminated by rats and the affected wells could be identified (Snow, 1855). This case yields the first known Geographic Information System (GIS) and demonstrates the added value of mapping, analyzing, and visualizing geospatial data for critical societal issues.

Later, the idea of mapping geographic information digitally arised and GIS have since been applied with the help of computers. First prototypes were developed in the early 1960 years leading to the first computerized GIS in 1963 (Esri, 2020). Nowadays, GIS have a wide range of application and are being utilized in a variety of different domains. There are multiple crossovers in the fields of GIS and Information Systems (IS) research such as Decision Support Systems (DSS), public services, and prediction.

GIS include two major components: the maps and layers that are being provided for users and the objects that are being mapped with the help of geospatial data. Today, open data policies like the Open Government Data Act or INSPIRE enable GIS users to obtain free geospatial data, and thus, the number of free available maps has increased in recent years. Then again, there is an increasing amount of digitally connected objects arising due to trends such as the Internet of Things (IoT). Here, not only more location data become available, but also more context-specific data like information about the object itself. Thus, the objects can be contextualized spatially by combining non-location data with location information.

With both trends——which highly depend on geospatial data——and more sophisticated functionality

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and new features of GIS evolving (Klein et al., 2017; Mobasheri et al., 2020), GIS should today more than ever be considered in interdisciplinary research. Studying GIS is the task of IS researchers just as much as studying Enterprise Resource Planning (ERP) systems, especially because GIS are the key to location data of (digital) objects and to define the role of location data in information systems. It is time to investigate information systems that incorporate location data and to ask what benefit GIS hold and what role location data play in the design of information systems.

Though the GIS research field is not new to IS since connections reach back to the 1990s, it has only been investigated rarely how IS research considers GIS regarding their design and usage. First attempts have been made to investigate the consideration of Spatial Decision Support Systems (SDSS) (Keenan and Jankowski, 2019) and Web-based SDSS (Sugumaran and Sugumaran, 2007). Further, the abbreviation GIS appears in many research papers, but this term often refers to other research topics, like Green IS. Though some scientific publications have examined the relevance of GIS for IS research (Keenan, 1997; Keenan and Miscione, 2015; Mennecke and West, 2000) an examination of how GIS have been considered in IS research so far and a derivation of research prospects on why GIS are needed for IS research in the future are missing. We posit that GIS research in IS is still at the very beginning and that there is still a leap to come.

The purpose of this paper is to examine the current state of scientific research regarding GIS in IS, to develop insights into the relevance of GIS for IS studies, and to provide an outlook on prospects for future research. Our research question is: In which research domains are GIS considered in the IS literature and what is the relevance of GIS regarding the design and usage of GIS and its functionalities? To answer the question, we conduct a systematic literature review (Webster and Watson, 2002) to review 97 publications that focus on GIS. By discussing the current state of GIS design and usage, we aim to identify research prospects for IS research.

This paper is structured as follows. In section 2, we present the theoretical background of GIS and related literature. In section 3, we explain and justify a structured literature review. In section 4 we present the results of our literature review. In section 5 we discuss the implications to derive four research propositions before concluding the paper in section 6.

2. Related Work

2.1. Geographic Information Systems

GIS have been designed and applied to explore and solve spatial problems throughout decades (Keenan and Miscione, 2015). In general, GIS can be defined as "a system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth" (Dueker and Kjerne, 1989, pp. 7-8). A GIS is based on geospatial data, a class of data that is enriched with location information, like with longitude and latitude values. GIS data differ from other digital data since they integrate the position of digitally connected objects (Ehlers and Schiewe, 2012). Within a GIS geospatial data can be handled in different ways. Generally, four aspects can be derived from literature, that define how GIS interact with geospatial data (Figure 1).

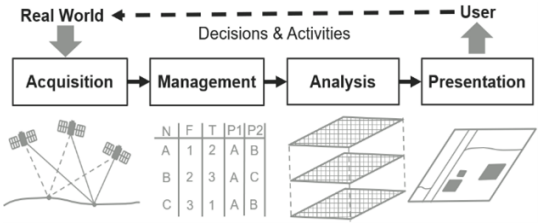

Figure 1. Properties of GIS (Ehlers and Schiewe, 2012).

First, the relevant geospatial data must be acquired. Geospatial data represent real-world objects, like buildings, the location of a person, or roads. Acquisition nowadays is mostly performed with GPS, tacheometry, aerial and satellite imagery, or laser-scanning (Hahulina et al., 2019). In a GIS not only geospatial data like coordinates are recorded but also the object's attributes, like the number of floors of a building or the personal data of a user.

Second, the acquired data must be managed in a GIS. Geodatabases form the base to organize and store these geospatial data. Within the geodatabase, the relations of geospatial objects are mapped. Through programs like INSPIRE, the integration of geospatial data from different external sources becomes feasible. The INSPIRE directive commits European member states to provide spatial data services for free, as well as the corresponding search, presentation, and download services, and to ensure the quality and validity of the data (European Commission, 2007). Thus, free data of good quality can be obtained from open data portals and the management of these data forms the foundation for

later analyses and data visualization.

Third, Geospatial data analysis is performed with the help of different tools offered by GIS. The data can be analyzed e.g., regarding their spatial proximity or their overlapping areas. Common analysis tools are amongst others overlay, boundary, and buffer analysis (Srivas and Khot, 2018).

Fourth, GIS allow for users to present or visualize the data. Presenting geospatial objects is advantageous for understanding geospatial problems (Albina, 2019; Mennecke and West, 2000). For instance, visualizing decision problems is beneficial for decision-making by emphasizing human visual capabilities (Bačić and Fadlalla, 2016). Thus, it is easier for a layman to understand the results of spatial analyses and to recognize spatial relations and dependencies at a glance (Dennis and Carte, 1998). Consequently, based on their new knowledge gained from GIS users can, in turn, affect the real world and its objects, by e.g., placing objects based on site selection analyses or evacuating people in hazardous areas. Thus, GIS are a powerful tool for analyzing critical societal issues like during the COVID-19 pandemic (Ahasan and Hossain, 2021) and bring new possibilities for the design of services and information systems (Irwansyah et al., 2020). Further, GIS are implemented within many companies today and affect the daily work (USC Spatial Sciences Institute, 2021). Thus, GIS should be considered as an essential part of a company's IT infrastructure.

Recently, GIS have been gaining increasing attention for two reasons. First, open data programs like INSPIRE bring the possibility to obtain free geospatial data provided by the countries and cities. This new data availability makes data acquisition and management obsolete in many areas since the data has already been surveyed and documented, for example in form of a web services. Thus, especially the analysis and visualization of these multitude of geospatial data bring significantly more opportunities. Second, trends like the IoT provide higher added value for users and providers by integrating GIS technology (Cao and Wachowicz, 2019). Here, new challenges mainly arise for data acquisition and management. The connected objects should acquire the data as precise as possible by integrating new technologies for indoor and outdoor positioning (Chen et al., 2018). Further, these acquired data mostly classify as big data, which must be managed accordingly (Usmani et al., 2020).

2.2. GIS in IS Research

Since GIS have been found to have deep connections with DSS, marketing and retail systems, analytics, and big data (Farkas et al., 2016), they are significant for the IS discipline. GIS offer a geospatial dimension for business decision-making and can improve the efficiency and effectiveness of solutions (Farkas et al., 2016).

Though GIS are no new topic and have been considered for over 25 years, there have been only a few attempts to find how IS research focuses on GIS through reviewing the existing literature. Though in the 1990s GIS have been found to have great potential for strategic choices (Murphy, 1996) and can facilitate decision support (Keenan, 1998), GIS have had little impact on IS research at that time (Keenan, 1997). Therefore, in the early 2000s, Mennecke and West derived future directions for the Management Information Systems (MIS) field by giving an overview over GIS research topics (Mennecke and West, 2000). For example, the introduction of geolibraries and other Spatial Data Infrastructure (SDI) initiatives are considered to be relevant to the IS community (Keenan, 2004). Further, GIS are considered to be a powerful tool for Marketing IS (Hess et al., 2004), for disaster management by using volunteered geospatial data (Horita, 2016), and for retail site selection (Aboulola, 2017). In 2014 Zhang and Yu found that GIS became an important research direction through an academic hot-spot analysis (Zhang and Yu, 2014). SDI, mobile computing, and public participation GIS have been identified to be the most relevant intersection topics between GIS and IS research (Keenan and Miscione, 2015).

Nowadays, GIS are gaining more attention especially because GIS enable to manage big spatial data collected by sensors, drones, and mobile phones, to improve decision-making and production decisions (Elsahlamy et al., 2021). Further, open data policies like INSPIRE enable users to obtain free, standardized geospatial data provided by the cities and countries. GIS bring new possibilities to analyze and work with distributed infrastructures, e.g., in smart grids (Ashkezari et al., 2018) and can be integrated with IoT solutions (Cao and Wachowicz, 2019). In 2018 there were an estimated 22 billion IoT-connected devices and for 2030 a rise to 50 billion of these devices is predicted (Strategy Analytics, 2019). Within an IoT context, geospatial data enable objects to obtain their current position and the location information of their surroundings. GIS allow for acquisition, management, analysis, and presentation of these data to e.g., enhance or improve existing services or create new IoT scenarios by knowing the structure of the obtained data. For example, in the field of agriculture, IoT is used to collect data through e.g., remote sensors, drones, and cameras. Here, GIS and big data play a critical role

for data evaluation and enable farmers to make better decisions and increase production (Elsahlamy et al., 2021). Also, open data can provide further information needed, like land management data and data on the surrounding vegetation, but also increases public awareness of sustainability and nutrition. GIS have the potential to improve the efficiency of enterprise and transaction systems and to create new opportunities by improving applications in their accuracy, efficiency, knowledge, and intelligence (Farkas et al., 2016). GIS is used amongst others for DSS (i.a. Aguilar-Rivera, 2019), spatial analysis (i.a. Caceres and Osailan, 2018), and prediction (i.a. Kucklick et al., 2021).

Though the IS community has also recognized the relevance of GIS (Farkas et al., 2016), with these new trends evolving and further research directions to come, GIS have not yet been paid sufficient attention to what specific contributions they can generate. Therefore, it is necessary to get an overview of what has been researched in this area so far and to give research prospects on why GIS are needed in the future regarding open data and trends like the IoT.

3. Research Method

We aim to identify, analyze, and systematize in which research domains GIS are considered in the IS literature and what their relevance is regarding their design and usage to give a research perspective.

To answer the research question, we perform a literature review (Webster and Watson, 2002). This method is suitable because, on the one hand, it allows us to analyze and systematize previous research results by aggregating and systematically reviewing prior research on GIS. On the other hand, a transparent, rigorous approach is adopted, which increases the traceability of the results (Vom Brocke et al., 2015). Since we identify research gaps and establish research propositions, our review classifies as a gap-spotting review (Schryen et al., 2015). When performing a literature review, there is a broad spectrum of potential contributions (Schryen et al., 2015). Since it is not our goal to close research gaps but to show research paths for other researchers, we derive research propositions based on the identified research gaps. To conduct our literature review, we apply three phases: Beginning, identifying, and structuring (Webster and Watson, 2002).

The first phase aims to set the boundaries of our work. We already defined relevant concepts in section 2. To be able to examine how GIS are dealt with, we conduct our search in the database AIS eLibrary, which is a standard search tool for IS research and includes leading journals and conference proceedings. In addition, we add eight more journals from the Senior Scholars' Basket of Journals and five recommended by the AIS Special Interest Group (SIG) GIS, which have been found to be especially relevant to the GIS research field. We choose to only include publications in relevant IS journals and conference proceedings, since we want to find out if classic IS research topics are being considered differently when integrating GIS or its functionalities. Further, we only search in papers' titles and abstracts, because we want to find publications, which focus on GIS and do not only mention it as a minor issue.

The second phase is about the identification of relevant literature (Webster and Watson, 2002). Therefore, we search for the word "GIS" and its variations within the title or abstract. These synonyms were combined into a search string as follows:

("GIS" OR "Geoinformation System" OR "Geographic Information System" OR "Geoinformationsystem" OR "Geo Information System" OR "Geographical Information System")

Though it is recommended by Webster and Watson to perform a forward and backward search, we decide not to conduct this type of search. We would have found only articles from other journals, which we excluded from our analysis set. With our initial search, we found 291 publications, of which 13 results are prior literature reviews that are excluded from the analysis but serve as a starting point for identifying the research gap and to position our work. We reviewed the literature in a first iteration and sorted out irrelevant results. Most publications that were excluded deal with Green IS, Green Infrastructure, or other concepts that have "GIS" as an abbreviation. Others only implement software or source code within a GIS environment but do not consider location specific data or study data privacy using GIS and geographical services as an example case, e.g., for data privacy of e-health applications (Adu et al., 2018). Also, tutorials and papers that analyze user behavior regarding GIS software were excluded. We identified 97 relevant papers (overview in Table 1).

In the third phase, we structure the literature with a concept matrix. Since we want to find out how and in which research domains GIS are considered in the IS literature, we analyze our findings regarding their research approach and their field of application. Therefore, the concept matrix features four categories of aspects.

The first category is *Research Method*. Research methodology is "an overall strategy of conceptualizing and conducting an inquiry, and constructing scientific knowledge" (Cecez-Kecmanovic, 2001, p. 143). Within our results we find five different types of research

	Database / Journal	Initial Results	Relevant Results
	AISeL	216	54
SIG GIS	Decision Support Systems and Electronic Commerce	16	11
	Communications of Association for Information Systems	8	0
	Telecommunications Policy	7	6
	Socio-Economic Planning Sciences	19	15
	Technological Forecasting and Social Change	6	4
Senior Scholars' Basket of Journals	European Journal of Information Systems	2	1
	Information Systems Journal	10	4
	Information Systems Research	2	1
	Journal of AIS	0	0
	Journal of Information Technology	0	0
	Journal of MIS	0	0
	Journal of Strategic Information Systems	3	0
	MIS Quarterly	2	1
	$\sum$	**291**	**97**

Table 1. Search results and publications included in the review.

approaches applied. First, conceptual research is used to provide the conceptual design of new artifacts (Gonzalez and Dahanayake, 2007). It examines existing theories and derives knowledge by combining and assimilating these concepts (Hirschheim, 2008). Second, Design Science Research (DSR) or design-orientated research "attempts to create things that serve human purposes" (March and Smith, 1995) and focuses on the design of IT artifacts (Hevner et al., 2004), which can be constructs, models, methods, and instantiations (March and Smith, 1995). Third, empirical research methods are deductive as they try to prove or disprove previously established assumptions (Bhattacherjee, 2012). Fourth, data-driven studies can be identified. Data-driven methods are inductive deriving hypotheses from data and data analyses (Maass et al., 2018; Shmueli and Koppius, 2011). Fifth, case studies examine the object of study in a real environment (Yin, 2014), being an inductive empirical approach.

The second category is *Relevance of GIS*. Here, we examine the way the authors design or use GIS. First, they can have a technical perspective on GIS, e.g., by designing interfaces, standardizations, or new GIS functions. Second, they can also have a focus on the design of GIS artifacts or data by e.g., designing data layers or GIS-based service systems. Third, the focus can be on using GIS or its functionalities, e.g., by applying GIS software like ArcGIS. Fourth, the analysis of the impact of GIS, e.g., in form of the relevance of maps or the meaning of GIS for decision-making processes, can also show the relevance of GIS.

In the third category *Properties of GIS*, we investigate, which of the four properties of GIS (acquisition, management, analysis, and presentation (Ehlers and Schiewe, 2012)), are addressed, indicating whether the authors have dealt with single aspects of GIS and its underlying concepts or regard the whole process.

The last category is *Research Topic*. Within a hermeneutic cycle—an iterative process of gaining knowledge—which "is influenced by a circle of (previous) understanding, gaining knowledge, and then achieving a better understanding" (Becker and Niehaves, 2007, p. 206), we identified different research topics. The topics are very diverse and can be clustered in two categories: method-related and domain-related topics. DSS, (3d) Imagery, Mapping, and Simulation, Prediction, (Process-) Modeling, Spatial Analysis and Optimization/Routing belong to the method-related topics, because they focus on improving or enhancing existing methods. Public Services and Cost/Value of IS belong to the domain-related topics as they regard domain-specific knowledge.

4. Results

Having analyzed all 97 papers we found that GIS have been considered since 1995. However, there are only about 3.6 new publications per year. Most papers were published in 2005 (10) and 2016 (15). Though there is no direct impact of the introduction of guidelines like INSPIRE visible in the number of publications, we find a slightly increasing trend (Figure 2).

Concerning *Research Methods*, the results reveal that most papers perform design-oriented methods (51.5%) or inductive research in form of data-driven studies (41.2%), while conceptual and empirical (deductive) research as well as case studies are only

applied rarely. Nevertheless, the number of publications is still low, making GIS a niche topic. Table 2 exhibits the number of papers addressing a specific concept or using a particular research method relative to all papers. A complete version of the concept matrix can be found in the online appendix [1].

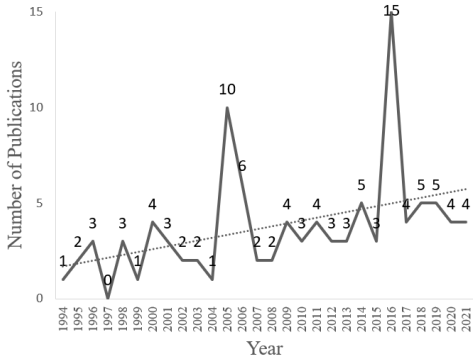

Figure 2. Number of publications per year with trendline.

In terms of *Relevance of GIS*, 67.0% of the papers use existing GIS software or GIS functionalities as a black box meaning that they do not extend or develop new GIS functionalities. Only 4.1% of the papers white-box GIS by developing new functionalities or focusing on the technical design or development of GIS and its functions. 26.8% of the research papers describe the design of IT artifacts or GIS data e.g., in form of layers. Within these papers, no design theories for GIS are derived. Design theories are "about the principles of form and function, methods, and justificatory theoretical knowledge that are used in the development of IS" (Gregor, 2006, p. 628). Consequently, none of the papers provide design theoretical knowledge about GIS.

Third, over 86% of the papers address all properties of GIS—acquisition, management, analysis, and presentation—like a process model that is used to analyze data in a comprehensible way. GIS is a tool that is simply used out of the box. Sometimes, the properties are not mentioned specifically within the applied methods but can be derived from the research procedure and the presentation of the results.

The last dimension is *Research Topic*. Here most papers use GIS for decision support (42.2%) and spatial analysis (41.2%) and in most of the cases, the authors use GIS or its functionalities as a black box. Remarkably, only 4.1% use GIS for prediction though spatial data has been found to improve predictive accuracy e.g., in house price and crime prediction (Corso et al., 2016; Kucklick et al., 2021). Further, 5.2% apply GIS in the context of public services and 12.4% use GIS for (process-) modeling, though it is beneficial for processes (i.a. Shakya et al., 2016). Also, GIS are found to be a helpful tool for optimization (Yu and Cai, 2004), but only 8.2% of the analyzed papers use GIS for optimization or routing problems. In general, many papers find the relevance and advantages of GIS for their research, e.g., increasing predictive power and making decisions more effective (e.g., Kucklick et al., 2021; Shakya et al., 2016; Zhu et al., 2016) but the number of new publications is rare and especially within the above-mentioned areas, GIS are not being used or designed frequently. Further, the papers analyze recurring problems reflected in the application fields most prominently spatial problems, spatial decision problems, or spatial optimization problems.

5. Discussion

Based on the identified research gaps, we derive four research propositions for future research on GIS (Table 3). These propositions serve as a starting point for both the exploration of novel areas related to GIS and the future ways of considering and utilizing GIS.

The analysis has revealed that GIS have been discussed in IS research for decades. However, GIS are still a minor research area which is shown by the small number of publications. Also, GIS tend to be investigated only superficially since most papers use GIS as a black box and do not develop new functionalities or focus on a specific property. The definition of GIS has not changed since the concept has been adapted to IS research. Hence, the GIS field is old but consistent and represents a niche with few publications. Compared to other information systems like Business Process Management Systems (BPMS), GIS are considered rather infrequently. For example, in 2016 the largest number of GIS papers appeared with 15 publications, however, in the field of Business Process Management (BPM) there were over 90 publications in 2016 and the field of digital platforms issued 532 publications in this year (Bartelheimer et al., 2022).

Nevertheless, we posit that GIS offer numerous benefits for IS research, like increasing predictive power and making (decision) processes more effective through integrating geospatial data. Especially in the light of open data and trends like the IoT GIS enable to obtain location information of connected devices and to acquire, manage, analyze, and visualize these data. There are more data available, which means more opportunities to analyze and evaluate these data and to combine them with non-location data. Thus, new applications can be designed by focusing on GIS.

[1] https://osf.io/jwt4e/?view_only=5b55689fecfd48e9adace70a36e17027

Concept	Characteristic		Total Number	Percentage
Research Method	Conceptual		5	5.2%
	Design-oriented/DSR		50	51.5%
	Empirical (deductive)		12	12.4%
	Data-driven (inductive)		40	41.2%
	Case-Study		1	1.0%
Relevance of GIS	Technical Design / Development (GIS as a white box)		4	4.1%
	Artifact / Data Design		26	26.8%
	Usage of GIS / GIS Functionalities (GIS as a black box)		65	67.0%
	Analysis of GIS Impact		10	10.3%
Properties of GIS	Acquisition		91	93.8%
	Management		92	94.8%
	Analysis		92	94.8%
	Presentation		86	88.7%
Research Topic	Method-related topics	Decision Support	41	42.2%
		(3d) Imagery / Mapping / Simulation	10	10.3%
		Prediction	4	4.1%
		(Process-) Modeling	12	12.4%
		Spatial Analysis	40	41.2%
		Optimization / Routing	8	8.2%
	Domain-related topics	Public Services	5	5.2%
		Cost / Value of IS	6	6.2%

Table 2. Percentage share of the different concepts relative to the total number of papers.

Hence, we derive our first research proposition as follows:

Proposition 1 *While substantially more location-specific data become available through open data policies and smart objects, GIS can provide richer insights and support new application scenarios, generating new opportunities for research.*

It is particularly noteworthy that the research subject of GIS is under-theorized. There is hardly any conceptual research and deductive research is also strongly underrepresented, though these types of research methods heavily rely on existing knowledge and theories and, thus, enable to gain increased knowledge and skills (Gagnon, 1982). Instead GIS are still mainly seen as black box tools, e.g., for data analysis. Thereby, GIS are only used as a tool to analyze data as a supplier service instead of being considered as a class of information system for theorizing. Hence, the discourse of GIS in IS research is present but should be conducted at a theory level.

In general, information systems are studied on a deep level, e.g., there is a high number of mature literatures concerning BPMS, ERP systems, and DSS. The question remains, what is different about GIS compared to other information systems and why has the system class of GIS not yet been investigated in the same depth. Therefore, the characteristics of GIS as a specific class of IS should be examined. The theories developed regarding GIS may contribute significantly to the IS discipline in the future by making classical IS phenomena be better understood when analyzing them in the context of GIS.

For example, within the theory of workarounds ERP are a widely studied example. Workarounds are ”conscious adaptations of work activities that are not expected or specified to be changed in this manner” (Laumer et al., 2017, p. 335). ERP systems provide logical but often inflexible processes that frequently embody unrealistic requirements on users and thus, these users see a need for workarounds in order to achieve their goals (Alter, 2014), e.g., by using dummy data. Since GIS are a different type of tool, that includes geospatial data and does not provide such strict processes, a different perspective is necessary regarding the theory of workarounds.

Hence, we derive the second research proposition as follows:

Proposition 2 *GIS should be subjected to theorizing, to analyze, explain, and predict how they are used in organizations as a class of information systems.*

When regarding design-oriented research or DSR, it is essential to derive a design theory by abstracting the findings to create new knowledge and to be able to apply the results to other classes of cases (Gregor, 2006).

Insights from the Literature Review	Research Gap	Proposition
Total publications: 97 Largest number of GIS papers: 15 in 2016	Though there are more data available and, thus, more opportunities for data analysis, GIS are still an under-represented topic.	*While substantially more location-specific data become available through open data policies and smart objects, GIS can provide richer insights and support new application scenarios, generating new opportunities for research.*
GIS as a black box: 67.0% Conceptual research: 5.2% Empirical research: 12.4%	GIS are mainly used as a black box and lack theorizing.	*GIS should be subjected to theorizing, to analyze, explain, and predict how they are used in organizations as a class of information systems.*
DSR papers: 51.5% DSR papers developing design theory: 0 GIS as a black box: 67.0% All four properties: 86%	Design-oriented papers about GIS mainly focus on DSR, but do not examine how GIS ought to be designed.	*GIS must be considered as an object of design, to implement new functionality and to theorize on how they ought to be designed to solve business problems that cover spatial data.*
Total publications: 97 Conceptual research: 5.2% 91% of research topics are method-related	Conceptual research especially regarding the value (co-)creation in service systems is missing.	*We need to identify how GIS can contribute to superior value co-creation, as they are used by service providers and customers in service systems.*

Table 3. Research gaps and corresponding propositions.

The identified design-oriented papers focus on DSR but do not consider how GIS ought to be designed. In the light of new trends evolving like IoT, the IS community should not risk missing the opportunity to examine what is special about GIS and how GIS-based information systems ought to be designed.

Until now, GIS have been considered from a rather broad perspective. In most papers, all four properties of GIS—acquisition, management, analysis, and representation—are addressed, but no paper focuses on one of these properties. By taking a more precise view on specific properties, research could, for instance, further develop or enhance these characteristics. Developing entirely new methods, e.g., for the analysis or visualization of geospatial data using GIS, would also be conceivable. Up to now, GIS are mainly designed as a part of other information systems and appear as a black box, since they are not considered regarding their internal structural elements and functionalities, but as a complete system, which is regarded and utilized from a specified perspective, without considering the system class and its inner workings. However, it is necessary to examine how GIS ought to be designed in terms of emerging trends and new use cases and to look at the individual properties more closely. Thus, our third research proposition can be derived:

Proposition 3 *GIS must be considered as an object of design, to implement new functionality and to theorize on how they ought to be designed to solve business problems that cover spatial data.*

Further, it should be investigated how novel aspects of IS can influence value (co-)creation (Haki et al., 2019). It is unclear why certain services, such as in the context of IoT, may operate more effectively with the help of GIS than without GIS. Research should focus on whether and how GIS can be used to achieve new effects in socio-technical frameworks. Nowadays, service systems engineering is an important IS research stream, fostering the design of new types of services. Since service systems are socio-technical systems that enable value co-creation, the question remains what benefits GIS have to offer for designing these systems. Considering GIS might bring added value as geospatial data in smart service systems, for instance, user location data or the positions of smart products, can be analyzed with GIS in a service system's back-stage (Beverungen et al., 2019).

In recent decades, open data policies like INSPIRE have emerged and the relevance of digitally connected objects has increased. Many of the occurring challenges of topics have a location-based character. For example, in the scenario of smart mobility, cars can be equipped with sensors to obtain their physical surroundings like the position of other vehicles and be connected with other smart objects like traffic lights (Beverungen et al., 2019). Though solutions like mobility services work without geospatial data, GIS enhance the value

co-creation by e.g., giving the possibility to analyze and reveal spatial dependencies and enhancing the value (co-)creation. Thus, integrating GIS in the design and development of service systems has the potential to increase value for both—the provider and the user of a service system. In a service system GIS enable to incorporate technical components like sensors with location information as well as social components like interaction with users through their current location and communication through mapping and visualization. Hence, we derive our fourth research proposition as follows:

Proposition 4 *We need to identify how GIS can contribute to superior value co-creation, as they are used by service providers and customers in service systems.*

6. Conclusion

Mapping geospatial phenomena has played an important role for mankind since early historical times. Through cartographic maps not only navigation became possible but also the detection of until then unknown spatial relations by visualizing geospatial data. Today, it is possible to obtain free geospatial data through open data policies like INSPIRE and there is an increasing amount of digitally connected objects arising due to trends like smart grids and IoT. These are ground-shifting trends that strongly impact the use, development, and theorization of GIS. Though GIS have been found to improve the efficiency and effectiveness of solutions (Farkas et al., 2016) like for processes (e.g., Shakya et al., 2016) or prediction (e.g., Kucklick et al., 2021), and have been investigated within the IS community since the 1990s, our review revealed that GIS is still a niche topic in IS research. We found that especially a theory-building perspective on GIS is missing until today. GIS should receive significantly more attention and more theory development should be conducted in the field of GIS—based on empirical and conceptual research. Moreover, IS research should not only consider GIS as a black box but as an object of design to theorize on how they ought to be designed. Finally, their role in service systems should be explored to identify how GIS can contribute to superior value co-creation.

Limitations of our research include the choice of sources. We limited our search to the AIS eLibrary, the Senior Scholars' Basket of Journals, and journals recommended by the SIG GIS. Future research might take a closer look at e.g., geography journals to enhance our findings. Further, the search string includes the term "GIS" and its variations. Expressions like "Geographic Information Technology" have not been integrated into the search string, as we wanted to address the core of GIS and no broader concepts. Therefore, we acknowledge that other research would come to other conclusions and future research should include more expressions. Further, developing a research agenda is still pending. Thus, we call on other researchers to develop a research agenda, e.g., by conducting a Delphi study, collaboratively building on our propositions which can serve as a starting point to guide processes and enable the discussion.

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