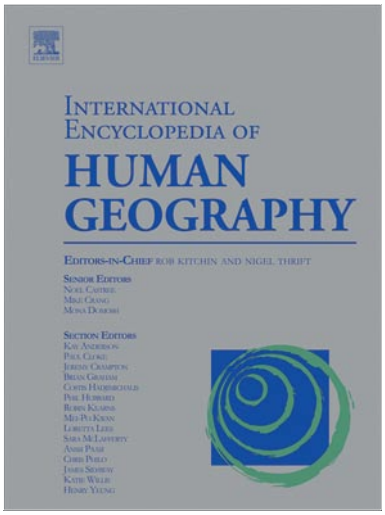

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Critical GIS

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Definition: Critical GIS

Critical GIS is a unique amalgamation of social theory and geographic information science (GIS) that is characterized by its emphasis on extending the functionality, as well as democratization of the technology. This dual social/technical emphasis gives rise to an agenda that is concerned with socioeconomic, feminist, epistemological, ontological, and participatory elements of GIS. While critical GIS emerged from a series of critiques from human geographers, it has been redefined as a creative blend of human and technical geography that has the potential to uniquely shape GIS and obliquely influence other information sciences. There are challenges, however, that range from a need to gain disciplinary approbation to the practical problem of transforming technology to respond to social concerns. There are a number of issues that contribute to an understanding of critical GIS. They include its history, relationship to science and technology studies (STS), feminism and GIS, ontology research, and participatory GIS (PGIS).

Critical cartography far preceded critical GIS with roots in late 1970s when David Woodward paired with Brian Harley to develop a *History of Cartography*. Harley is perhaps better known for revealing the critical dimensions of cartography. He claimed, for instance, that maps have always been a means of depicting and producing social relations. He used the famous example of the king's castle that is frequently illustrated in large size on feudal maps while whole villages comprising cottages are missing. Indeed, Harley famously concluded that the map is not the territory but a representation of social relations. It follows that maps not only represent but enable certain relations of power. This view corresponded to sociologist John Law's conceptualization of maps as a mechanism for ordering societies. Law noted that between 1400 and 1800, Europe underwent transformations in social organization during which maps were critical for the representation and imposition of the 'truth'. Harley's legacy was in drawing attention to the unity between maps and power. Raper and Livingstone applied this structure to GIS arguing that data models are theories of the world. In this view, measurements are not taken without being informed by theory. In addition, representation is closely linked to ideology – a key tenet of critical GIS.

Critical GIS began to converge as an identifiable subdiscipline in the early 1990s as human geographers became aware of the increasing importance of GIS within geography. While some human geographers were suspicious of GIS' claims, others were concerned about the direction that GIS was leading the discipline. Critiques of GIS that focused on apprehensions of the effects of GIS on geographical knowledge and disciplinary epistemologies were first published in 1990. The next 5 years witnessed many publications by human geographers who were often skeptical about the role that GIS could productively play in the discipline.

Critiques of GIS by human geographers can be characterized as three distinct periods. The first, between 1990 and 1994, was characterized by rather fierce criticisms of GIS and spatial analysis by human geographers. Though many of these analyses were warranted – especially as GIS had been oversold in its early days – the tone of the papers was frequently vituperative. The arguments were, however, relevant as authors appealed for a more thoughtful and reflective GIS that might concern itself with epistemological and ontological implications of spatial analysis and representation. The flavor of early critiques of GIS was, however, unwittingly antagonistic.

The second period of critique took place between 1995 and 1998. Over 40 papers were published in 1995 alone by a mix of human geographers worried about the implications of a widely disseminated GIS. Many of these publications were included in two key 1995 anthologies: *Ground Truth* edited by John Pickles, and *GIS and Society*, a special issue of *Cartography and GIS* edited by Eric Sheppard. Concern was expressed that GIS best served large corporations and public agencies rather than the disenfranchised. Critics were especially skeptical about links between the quantitative revolution and GIS. Human geographers largely regarded the quantitative revolution as a mechanistic approach to geography and worried that GIS propagated many of the underlying principles. Critics were also suspicious that GIS was overly masculinist and an invasion of spatial privacy. The period of critical GIS from 1995 to 1998 was thus characterized by a mixture of substantive issues and theoretical concerns that predominated in human geography.

During this period, however, a number of critics began to build liaisons with GIS researchers in the field. The groundwork for this closer collaboration was laid by the US-based National Center for Geographic Information Analysis (NCGIA) Initiative 19 *GIS and Society*. Initiative 19 provided the basis for close contact between critics of GIS and academic researchers, and led to a more relevant set of arguments about the role and potential of GIS in society and within the discipline of geography. Thus by 1998, critics of GIS were more engaged with the

technology. There was also increasing acceptance that GIS occupied a permanent place in the discipline of geography. More importantly, by the late 1990s, critical GIS had moved from an antagonistic activity to a means of positively affecting a technology that was being widely adopted in other disciplines and in the commercial sphere.

This trend toward a potentially positive, creative critical GIS can be attributed to the large number of collaborative efforts between GIS researchers who were receptive to critiques from human geographers and other critics. Moreover, early critical GIS spawned recognition among GIS scholars that critical geographers could identify social and even technical implications of GIS technology. The cooperation depended, however, on GIS researchers being willing to extend the scope of legitimate research questions in the discipline.

The beginnings of this dynamic cross-fertilization were spawned during a meeting at Friday Harbor in 1993. The Friday Harbor meeting was unusual by any standards given its goal of reconciling disciplinary antagonisms. That initial conference was spearheaded by Tom Poiker who was perturbed by rumblings of discontent about GIS from human geographers; the organizing committee included Eric Sheppard and John Pickles both of whom had recently published critiques of GIS in the *Professional Geographer*. The Friday Harbor meeting created a precedent of bringing together diverse group of scholars from within the discipline of geography, and began what is arguably the unique discourse of critical GIS.

Dissemination of collaborative work between critical theorists and GIS scholars has aided the cross-fertilization that characterizes critical GIS today. A meeting, organized by Francis Harvey in the spring of 1999 and held in Kentucky brought together critics of GIS, as well as well-known classification theorists Geoff Bowker and Susan Leigh Star. Selected papers from this meeting were subsequently published in *International Journal of Geographical Information Science*, thus increasing the opportunity for dialog between the technical and critical communities. More recently, Mei-Po Kwan, Francis Harvey, and Marianna Pavlovskaya organized a conference on critical GIS at Hunter College in 2001. Papers from this conference were published as a special issue of the journal *Cartographica* in 2005. Likewise, David Unwin sponsored a meeting on Spatial and Temporal Representation in GIS in the UK in August of 2001. The meeting was designed to bring together critical theorists and GIS analysts to develop an agenda for diversifying representation in GIS, and incorporating time-based analyses. Papers from that meeting were published in 2005. Through efforts such as these, critical GIS was incrementally disseminated to a broader community of human geographers and information scientists.

Critical GIS, Science Wars, and Social Constructions of Technology

The 1990s witnessed a phenomena known as the science wars in which critics of science pointed to social influence on scientific constructions of knowledge. The subsequent emergence of critical GIS has roots in these debates though it cannot be subsumed under the rubric of the science wars. To do so undermines the considerable efforts made by the GIS community to accommodate criticism as evidenced by NCGIA I19 and the subsequent Varenius Project. Like earlier NCGIA initiatives, the Varenius Project was funded by the National Science Foundation under the NCGIA rubric. Varenius is named for the seventeenth-century Dutch geographer, Bernhard Varenius, who initiated mathematical bases for geographical inquiries. The project was directed toward research in three areas of geographic information science: (1) cognitive models of space; (2) computational aspects; and (3) 'geographies of the information society'. For the critics, it trivializes their criticism by assuming that they are repeating axioms from STS. It also fails to recognize that many STS researchers focus on fields other than their own. In STS, sociologists study and critique physics or biology. In geography, however, critics have turned their attention to their own field, an area in which they have considerably more stake. It also discounts the willingness of critics to work with GIS scholars.

At the core of the science wars was the epistemological privilege enjoyed by science and the degree to which science is culturally influenced. Social scientists were increasingly critical of science 'proper'. Proponents of science defended themselves with the publication of books and articles intended to undermine the politics and motivation of its critics. The science wars were made truly contentious by the 1996 publication of an article called 'Transgressing the boundaries' by physicist Alan Sokal. Sokal putatively discussed parallels between twentieth-century mathematics and physics and their relation to ongoing work in STS. His was a dense, meandering text that should not have evoked much comment nestled in the company of excellent companion pieces on the cultural construction of science. On the day of its publication in *Social Text*, however, Sokal published an exposition in *Lingua Franca* in which he claimed that his paper was a hoax, a parody of attempts by social scientists to link science and culture. *The New York Times* considered this trick worthy of an editorial and Sokal, himself, was eager to talk to the media. The science wars went public. In the aftermath, there were many rounds of debate.

Critics of GIS from human geography neither exclusively emphasized the social construction of GIS nor did they, for the most part, engage with the theoretical critiques emerging from STS. Staples of STS such as

actor-network theory (ANT) and the symmetry of true and false claims were eschewed in favor of epistemological arguments, and specific attention to the 'effects' of GIS, as well as the direction of the discipline. Debates over GIS in geography were motivated by a genuine desire on both sides to steer the discipline in an appropriate and responsible direction. The history and content of those debates is as distinguished by its differences from the science wars as its similarities. In each instance, social scientists initiated a critique of their counterparts in science and technology. It is the nuances of the debate 'within geography' that mark critical GIS as it is emerging in the early twenty-first century.

Critical GIS is clearly related to STS though the two remain distinct. Critical GIS is, first of all, situated within geography. It involves a very different set of negotiations to study one's own discipline. STS tends to focus on disciplines outside of the researcher's domain. John Law a leading sociologist of science, for instance, spent considerable time following scientists 'in action' in Daresbury Nuclear Laboratory. Critical GIS researchers focus on our own discipline, seeking to uncover contingent and social practices that contribute to the development of GIScience.

As outsiders, STS scholars can afford to be more aggressively critical of science. Donna Haraway has discussed the use of tactics by social theorists to undermine science. She expresses caution about attempts by social constructionists to demonstrate that science is just another text, like history, produced for the power and profit of dominant players. Schuurman and Pratt argued in 2002 that there is an inside/outside to critique. External critique has little invested in the outcome while internal critique is necessarily cautious and careful, as it has a stake in the future of the technology. To be constructive, critique must care for the subject. While critical GIS began as an external critique with an attendant harshness, it has decidedly coalesced as an influence within GIS that is wedded to the goal of a better technology. Critical GIS shoulders the burden of responsibility to a discipline while simultaneously deconstructing it bases.

In addition, critical GIS has been differentiated historically from STS by its methodologies. Critical human geographers employed few STS tools until recently. In the latter half of the 1990s, a few critical GIS researchers began to use ANT to describe the development and dissemination of GIS technology. ANT is a systematic method of tracing the development of sciences and technologies through social processes. Frequently, ethnographic techniques such as interviews are used to track the development of ideas and technologies. Such studies are aided by the analysis of 'inscriptions' related to the technology such as publications, press releases, or grant proposals that authenticate the science in an iterative fashion. Though ANT has been instrumental in illustrating that science and technology depend on social processes to develop, it is limited in that it tends to emphasize the science as consequence of sociology with few links to materiality. This leads very easily to a rejection of STS claims by scientists who frequently rely on a realist/empiricist interpretation of the world.

If critical GIS is to remain a system of constructive internal critique, then it must find ways to communicate social processes to scientists in a manner that is relevant to their own work, and acknowledge a fundamental materiality. A framework that satisfies these demands was described by David Demeritt in a 2001 article in the *Annals of the Association of American Geographers*. Heterogeneous constructivism acknowledges that natural systems including geographical phenomena are influenced by a broad range of social practices, but, are nevertheless linked to a fundamental reality. It follows that we cannot ascertain the degree to which science reflects phenomena 'as they truly are', but accept that they are a hybrid reflection of material and social processes. This iteration of STS bestows an epistemological freedom on critical GIS research while emphasizing that social influences on science and technology modify but do not substitute for material reality. By integrating heterogeneous constructivism – with its implicit recognition of the politics of knowledge – critical GIS is better positioned to successfully communicate insights to developers and users of GIS.

Heterogeneous constructivism is the rubric for a recent trend in critical GIS that points to social influences in the development of technology. This technique can point to specific instances where GIS is affected by, or constrains social processes. For instance, generalization research in GIS was delayed by a cartographic tradition that stressed map simplification rather than database, or model, generalization. Mei-Po Kwan has found that conventional spatial methods for evaluating accessibility suffer from gender bias, and are inadequate for demonstrating the space–time constraints in women's lives. In both instances, points of social influence were identified in GIS construction. Heterogeneous constructivism is a tool for studying the algorithmic basis for GIS. It implies a more GIS-savvy researcher who is interested in questions that extend beyond social construction to reconstruction.

Feminism and GIS

External critiques from human geographers tend to be concerned with epistemological assumptions and social repercussions, while internal critiques have focused on the technical. However, there is a further difference. Internal critiques have a stake in the future of the technology while external ones tend not to. To be constructive,

critique must care for the subject. A feminist approach urges a change of attitude in critiques of GIS, from morally and intellectually superior outsider to a critic who is more open about his/her complicities in shared circuits of power and intellectual traditions. This change in direction must be accompanied by a refocusing of the objectives of criticism, from that of exposing error to the task of uncovering the production of truth.

Understanding the effectiveness of GIS and the production of truth within and through GIS, requires a specialist's knowledge of it. Feminists may see tactical ways of using existing GIS technologies to further goals for social justice. Mei-Po Kwan argued, for instance, that critical GIS in a feminist context needs to be more reflexive in order to produce truths otherwise concealed. Likewise, Kwan has demonstrated that it is possible to develop feminist discourses in GIS using visualization. The technology can, in fact, be used to enrich feminist geography and practices. Despite these promising developments, feminist geography and GIS – two very robust elements of the discipline – remain ironically separate.

Critical GIS and Ontology Research

Early critiques of GIS focused on the need for practitioners to examine the ontologies they worked with and the epistemologies of their practices. Ironically, mainstream GIScientists took up the call to address ontological and epistemological issues. In the process, they have integrated many of the concerns expressed in early critiques but within the technological framework or discursive regime that underlies GIScience. There is a powerful divide between the abstract concepts that are used to articulate critiques of GIS and the formal language – ultimately code – that is required to implement changes to the technology. Concepts such as subject–object dualism, or epistemological intransigence do not translate neatly into machine language. As a result, it has been easier for GIScientists to develop computable mechanisms for inclusion of multiple ontologies in a GIS that can represent multiple points of view.

Ontology research in GIScience has increasingly focused on problems with categories and their failure to travel well across the boundary between conceptualization and computation. For example, the European Union (EU) has developed a vegetation classification system based on biotypes. Some conservationists have noted, however, that UK classifications do not match Russian vegetation types well. Also, some Irish vegetation types are unclassifiable using the system. The classification systems reflect not only different frames of reference, but were developed under different vegetative and climatic regimes. Neither reflects a universal reality but local settings and their institutional cultures. Ontology research in GIS is charged with developing a mapping from multiple spatial ontologies to database models with minimum loss of meaning.

Multiple models for achieving this goal have been developed under the rubric of ontology research. One method uses the analogy of node-arc structures from graph theory. In this scenario, nodes are equated with conceptual elements (intrinsic properties) and arcs with relationships (extrinsic properties). The goal of this approach is to identify close or near concepts and tag database elements so that proximate concepts and entities can be linked. Methods of addressing this problem also include restructuring databases to illustrate links between semantic objects based on context. Another method for including multiple ontologies is the use of inclusion rules for determining which elements belong together. Each of these methods is linked by emphasis on including context in the final database as a means of ensuring that the terms of classifications can be recognized in different settings. Through ontology research, GIScientists have contributed to the body of research called critical GIS.

Participatory GIS

A key contribution of critical GIS has been to include communities in the discourse of GIS. PGIS is envisioned as a flexible system, comprising a suite of integrated methods and technologies that, through the incorporation of multiple perspectives and a diversity of alternative information forms, facilitates collaborative planning efforts, supporting inclusive public participation in decision-making processes. It is both a computer-based system employing a collection of software tools and an interactive human process. The public participation process involves an exploration and description of the problem, exploration and evaluation of solutions, creation and evaluation of alternatives, feedback, and finally prescription of an acceptable approach. It aspires to increase public involvement in defining, analyzing, and resolving issues related to space and location, especially for groups traditionally excluded from such processes. It also represents the expansion of GIS research to the sociopolitical implications of public use and the role of technology in democracy.

Since the development, design, and implementation of GIS is also social process, the technological components cannot be isolated from the sociopolitical context of its application. GIS has been perceived both as an empowering and marginalizing force upon community groups, shaping and being shaped by associated politics and power relationships. Harris and Weiner argued in 1998 that empowering and disenfranchising processes both occur simultaneously depending on perspective. Accordingly, societal consequences have become a

priority within PGIS research. PGIS research studies the value GIS offers marginalized groups, the nature of their application, and further develops innovative approaches, technologies, and institutions to support their empowerment.

A strong interest in promoting public participation and understanding the underlying mechanisms and methods began to develop in the late 1960s and early 1970s. By the late 1970s and 1980s, substantial criticism had developed toward the prevailing scientific approach to planning, which failed to recognize the link between the act of planning and the implications for the society being planned while defining spatial components in isolation from their contextual situation. This encouraged the new perspective that planning must be integrated within the framework of diverse interest groups, rather than existing independently from its sociopolitical context.

The principle goal of the PGIS movement is to promote the empowerment of citizens by facilitating collaborative planning such that community groups, who were traditionally excluded from planning processes by the technocratic elite, have the ability to participate in policy-related decision making. This is embodied in a system of tools, techniques, and approaches, both technological and social. Another aim is to maximize accessibility, both in physical access to the system and comprehension of its functionality. The incorporation of local knowledge is a crucial advantage not only for community members but for planners who recognize that local knowledge is often superior to conventional 'expert' knowledge of a place and may contribute to stronger analyses.

Dissemination of information is critical for the strength, progress, and success of community groups. Community groups may use geographic information for specific administrative, strategic, tactical, and organizational purposes but this underlies the broader theme that better information allows community stakeholders to ask better questions about the issues about which they are most concerned. PGIS is capable of providing citizens with information and dissemination options not only by bringing together multiple perspectives but also through the capacity to act as portal to government and professional data. The power to assimilate data from multiple sources and formats increases the depth and diversity information available, enables communities to better represent their conceptualization of space, and aids stakeholders in gaining better understandings of the complex interrelationships that underscore public policy decisions. Technological components of this system must be designed such that the ease of use and comprehension supports effective use by all sides of public debates. The implementation of PGIS is also greatly influenced by the local social and political context of its use. Greater depth of involvement also gives every project the potential to improve the community–government dynamic.

PGIS has perhaps been the most effective form of critical GIS. It has transformed the area of criticism into a constructive exercise with the participation of millions of people worldwide. Its successes have furthered the goals of critical GIS because: (1) PGIS has been forced to develop user-friendly interfaces in order to increase accessibility of GIS; and, as a result, (2) GIS has been disseminated to a broader circle of users thus democratizing the technology.

Critical GIS in the New Millenium

Critical GIS has been a part of geography's landscape for long enough to have a history and respected role – articulated by Eric Sheppard in 2005. Sheppard examined the history of critical GIS, drawing attention to its key moments. He concluded with a caution that critical GIS scholars must continue to pay attention to the suppositions that animate the technology and their interpretations of it. David O'Sullivan also summarized the progress of critical GIS in 2006. O'Sullivan characterized critical GIS as a means of theorizing GIS through understanding its origins and development. This is reminiscent of Harley's attention to the historical relationship between power and mapping and consistent with many of the goals of critical GIS thinkers. O'Sullivan argues that critical GIS will remain relevant so long as it hosts an intellectual fusion between technologists and theorists. Marianna Pavlovskaya has articulated means for combining qualitative approaches in GIS with the quantitative and illustrates that the two approaches to research have never been separate. Certainly that is a tenet of critical GIS.

The goal of critical GIS to extend the functionality of GIS while democratizing it has been enhanced by influences from STS and critical geography, feminist geographers, ontology research, and the successes of PGIS. The future of critical GIS hangs, however, on the willingness of geographers and users to engage both theoretically and technically with the systems and science of GIS.

See also: Actor-Network Theory/Network Geographies; Critical Cartography; Feminism, Maps and GIS; Geodemographics.

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