Integrating GIS and Participatory Mapping in Community Development Planning

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Abstract: Geographic information and spatial data have played increasingly important roles in development planning and environmental decision making from top-down management to grass-roots participation. This paper presents a series of case studies that integrate traditional participatory mapping methods directly with ArcGIS and ArcPad and evaluate potential applications of new digital pen technology. This unique combination of mapping media allows community groups and project-affected people to work with familiar hand-drawn participatory maps and mapping techniques that retain the culturally appropriate symbols and use familiar media, while still taking advantage of the quantities and speed of information exchanged through GIS. These new maps have the appearance of a traditional participatory map, but each icon accesses the database of spatial information typically stored in a GIS. Overall, this paper focuses on the implications of this new tool for improving project-information exchange, stakeholder communication, and participatory decision making in a wide variety of development programs.

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Introduction

Recent decades have seen significant changes in both local and global development planning efforts. Community-based organizations and advocacy groups around the world have advanced the concept of "environmental justice" and issued calls for more inclusive dialogues among planners and local stakeholders (Fiorino 1990; Renn, Webler et al. 1995; Sexton, Marcus et al. 1999). At the same time, research on sustainable practices has emphasized the importance of "resident experts" in implementing environmentally-sound development decisions (Chambers 1983; Chambers 1997; Coenen, Huitema et al. 1998; World Bank 1998; Fischer 2000). In response to this concurrent international emphasis on stakeholder consensus and indigenous knowledge, public and community participation have moved to the forefront of both large- and small-scale development and environmental agendas (Stiglitz 2002). This shift in thinking has dramatically increased worldwide efforts to communicate with the public, to understand local responses to specific projects and risks, and perhaps most critically, to gain public acceptance to counter rising opposition and promote sustainable decision making (Beierle and Cayford 2002).

The transformation of development priorities and practices has drawn widespread attention to a variety of information and communication technologies (ICTs) for their potential to facilitate participatory development that is both inclusive and environmentally-sensitive. The international demand for these technologies is evident in initiatives, such as the UN Millennium Development Goals (MDGs) and the World Summit on the Information Society (WSIS), which emphasize that effective development depends on equitable information access and global knowledge sharing (United Nations 2000; WSIS 2003). More recently, however, the demand for ICTs has been paralleled by criticism of the impacts of technocratic ideals on social processes. These impacts have given rise to extensive literatures on *appropriate technology* and *the digital divide* (see (Yapa 1991; Hutchinson and Toledano 1993) for examples related to spatial technologies). Although, many ICTs have improved their social interfaces in response to these concerns, in contrast, the information handled by these technologies has become increasingly complex.

Massive quantities and highly sophisticated presentations of data have resulted in a divide beyond a lack of access to technology and even a lack of access to information. This new divide _ between information and communication _ is evident in a variety of global development projects, where various stakeholders and diverse groups require common information about a project, but understand and use this information very differently from one another. In some cases, information is both available and relevant, but it is represented in a form that is too general or too specific to be useful for the intended audience.

Geographic Information Systems (GIS) and technologies provide one of the most striking examples of this paradox. Because decisions related to both development and the environment are inherently grounded in the physical locations of key populations, resources, and issues, spatial information is central to these choices (Brodnig and Mayer-Schönberger 2000). The abilities of GIS to synthesize a wide variety of data and analyze complex spatial

relationships has, therefore, made it an essential planning tool for projects ranging from transport planning to forest conservation to infrastructure siting. As GIS have been extended to more complex and diverse applications, the resulting maps and output from the system have also become increasingly intricate, and arguably, divergent from the users and communities the technology was originally intended to serve (Dunn, Atkins et al. 1997; Abbot, Chambers et al. 1998).

This divergence has led to critical assessments of the social implications and applications of GIS and its outputs through forums such as the Varenius Initiatives (Goodchild, Mark et al. 1997). In spite of these efforts and the rapid growth of new Participatory GIS (PGIS) and Public Participation GIS (PPGIS) research areas, GIS technology and its maps remain largely focused on characterizing and analyzing attributes of locations, instead of populations and livelihoods.[1] This paper argues that with the changing nature of development, the increasing emphasis on social and environmental sustainability, and the global attention to community-level planning, GIS need to move beyond conventional representations of *where* people live to describe more effectively the dynamics of *how* people live. This subtle distinction is central to this paper.

Since its inception, the potential of a GIS to illustrate collectively numerous aspects of a location has been its primary strength; however, with the emphasis on participatory information, this strength of the technology has also become a fundamental weakness of its output. GIS maps with multiple layers of information that include *all of the features* of a selected area, such as schools or green spaces, are now widely recognized as representing only one possible reality, and a collective reality at that (Chambers 1997). Rarely do all residents of a community interact with every school or park in their region, let alone in similar ways or for the same reasons. Individuals' connections with their physical surroundings are the product of their unique priorities, perceptions, preferences, and potentials. In other words, populations are not homogenous, and *where* people live only forms a starting point for *how and why* they live there.

Although the overarching picture offered by GIS maps is important, this view is no longer enough. Effective development, as defined by the Millennium Development Goals (MDGs), requires the disaggregation of both actual and perceived spatial relationships by gender, age, and income, among other characteristics, to understand and address the differential impacts of development among diverse populations. These impacts are widely acknowledged and studied, but neither conventional nor participatory GIS currently serve the related information needs effectively. The processes of data collection, integration, and map creation using GIS and participation-based GIS, have only recently begun to change in response to these distinctive dynamics of community development (Weiner, Harris et al. 2002).

[1] For more information about PGIS and PPGIS (and the distinction between the two), the IAPAD website (http://www.iapad.org/) is an excellent source of examples and references. (Accessed: 20 May 2005)

In contrast a variety of existing methodologies for facilitating participation have emerged to fill this gap and promote equitable development (Chambers 1994; Cornwall and Jewkes 1995). One such popular tool for spatial data collection is participatory mapping. The term participatory mapping, as it is used here, is defined broadly as any combination of participation-based methods for eliciting and recording spatial data. Specific examples include sketch mapping, scale mapping, and transect walking, among others (Chambers 1994; World Bank 1996). These methods are referred to within PGIS and PPGIS literature as counterparts to GIS for their ability to capture individuals' or groups' perceptions of local issues and development efforts (see (McCall 2003) for examples). Although participatory maps, in contrast to GIS, describe *how* people live, many of these methods are limited in their usefulness. Often the process of data collection is extremely time-consuming, and the resulting information is difficult to compile and unwieldy for effective use by decision makers (Tripathi and Bhattarya 2004).

Given the complementary characteristics of participatory mapping and GIS, this paper proposes to bridge the growing gap between spatial information and stakeholder communication in community development planning by integrating these two methodologies. The combination of participatory methods and GIS is not new, but this research is unique in its collective focus on 1) the participatory inputs into GIS, 2) the direct users of GIS software, and 3) the indirect users of GIS output. The goal of this work is to develop a medium for participation that retains the elaborate information storage and consolidation capacities of GIS while simplifying and tailoring the graphic display to different audiences using elements and attributes of traditional mapping.

In general, research combining participatory mapping and GIS is in its early stages. In recent cases where the two tools have been used jointly, the methods and results have been largely project-specific (Mapedza, Wright et al. 2003; Mbile, DeGrande et al. 2003; Robiglio, Mala et al. 2003; Kienberger, Steinbruch et al. 2005). Although these studies provide important and detailed applied examples, they do not, individually or collectively, establish any holistic strategy for adapting the approach to projects with different needs and objectives. Similarly, these efforts concentrate on specialized aspects of participation, namely data collection and integration, in contrast to the work here, which addresses all of the "building blocks" of participation, including: information collection, integration, and dissemination; stakeholder communication; and participatory decision making.[2] This paper develops a broad theoretical structure and a series of applied examples to both generalize and operationalize the proposed process.

[2] The vast literature on participation includes detailed evaluations of many types of stakeholder involvement (Arnstein 1969) and their related participatory tools and methods; however, Vajjhala and Fischbeck (2005) suggest that all of these levels of participation can be more simply characterized as being made up of various combinations of three basic elements- information gathering and dissemination, stakeholder communication, and participatory decision making- and their associated feedback loops. Effective participation at any level requires an assembly of these 'building blocks' to address specific project goals and stakeholder needs.

The next section, Section 2, builds on these recent examples from development literature to describe briefly why the specific combination of participatory mapping and GIS is important and how these two complementary methodologies can be merged into *participatory digital mapping*. This section also develops a unique theoretical framework for planning and evaluating a variety of participatory mapping and GIS efforts. Sections 3, 4, and 5 then give three different examples of strategies for implementing this new method and the resulting maps within three case studies of community development planning in the Pittsburgh region. Finally, Section 6 concludes with a discussion of the implications of this approach for sustainable planning in a variety of developed and developing world applications.

The Dimensions of Mapping

Traditionally, there has been little overlap between the users, audiences, and objectives of GIS and participatory mapping; however, with the recent changes in development practices, mapping professionals and projects in these domains have gradually come together (Brodnig and Mayer-Schönberger 2000; Weiner, Harris et al. 2002). Specialists in participatory methods or in GIS have each extended their respective research areas to include aspects of the other; but many of these efforts remain grounded in the strengths and weaknesses of their points of departure. For example, PGIS and PPGIS efforts typically retain the complexity and precision of a GIS, while participatory maps in GIS often remain informal, socially focused, and locally relevant.

The growing movement toward integrating participatory methods and GIS highlights that fact that neither approach alone currently meets society's changing information needs (Weiner, Harris et al. 2002; Mapedza, Wright et al. 2003; Mbile, DeGrande et al. 2003; Robiglio, Mala et al. 2003; Kienberger, Steinbruch et al. 2005). Combining participatory mapping methods and GIS requires a clear assessment of their respective strengths and weaknesses for different applications and is essential for mapping professionals, development planners, and community stakeholders alike. In spite of this awareness, there has been little critical analysis evaluating the effectiveness of current methods. This problem is not unique to mapping. Because of the diversity of participation projects, their contexts, and their objectives, many participatory strategies have been applied in the absence of standard definitions and measures of success (Chess and Purcell 1999). This phenomenon is perhaps best described by the phrase that "when you have a hammer, all the world looks like a nail." Avoiding indiscriminate applications of participatory tools, such as mapping, requires a clear framework for planning and evaluation.

This paper makes a step toward defining this theoretical framework based on three key "dimensions" shared by both participatory mapping and GIS. Figure 1 illustrates how the balance between 1) spatial and social objectives, 2) accuracy and precision in map displays, and 3) representativeness and comprehensiveness of spatial information collectively define the

fundamental attributes of different mapping methods and their resulting maps. Each of the attributes on the left side of the three dimensions focus primarily on the issues surrounding *how* people live and are connected more strongly to participatory mapping, and those on the right side characterize *where* people live and are more strongly associated with GIS. The combination of GIS and participatory maps into participatory digital mapping at the center of the figure seeks to balance these attributes and create a dynamic equilibrium across all three dimensions.

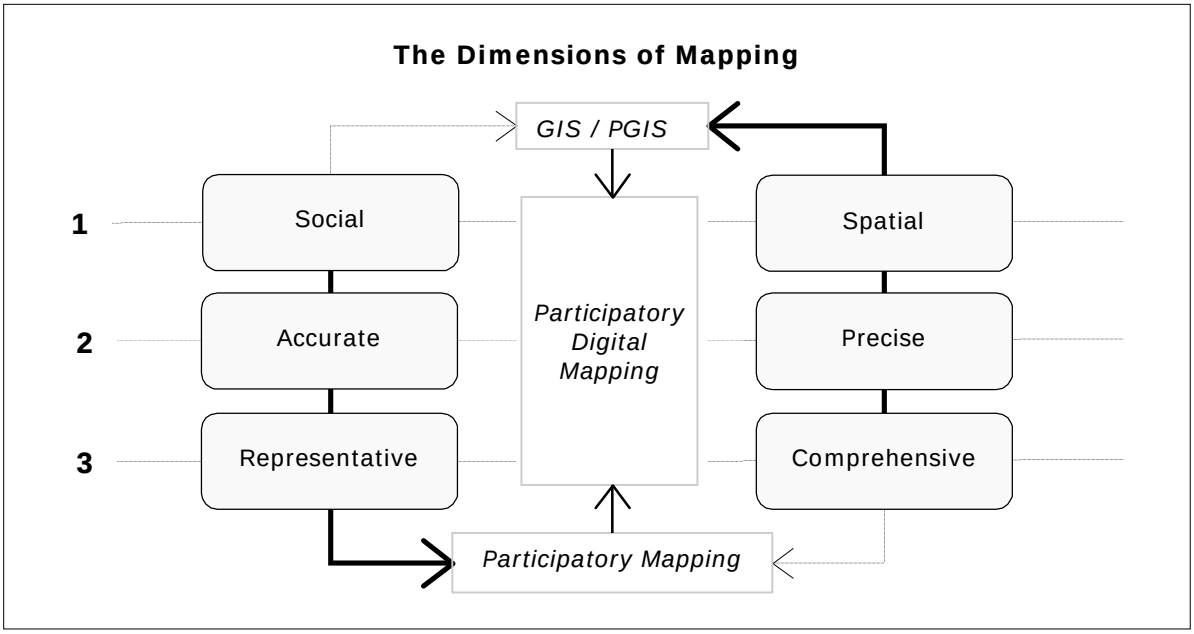


Figure 1. Diagram of three dimensions of paired attributes shared by GIS and participatory mapping.

It is important to note here that the attributes along each dimension are not opposites nor are they exclusively associated with either GIS or participatory mapping. Instead these attributes illustrate the dominant values and objectives most commonly associated with each method. The interactions among them make up the unique characteristics of different maps and applications. Even within the domains of participatory mapping and GIS, there are varying emphases on these different characteristics. For example, certain types of participatory maps, based on transect walks or scale mapping, demand far more spatial precision than others, such as sketch maps. Similarly, some GIS maps focus more strongly on social accuracy than others. For example, a map could represent a village as a single abstract point on a GIS layer or as a collection of polygons showing the dynamic changes in village boundaries, depending on the availability of relevant social data. Taken as a whole, the characteristics of maps along all three dimensions are dynamically driven by their underlying mapping methods and how the selected data is elicited, integrated, and displayed.

In the case of the first dimension, the primary purpose of participatory maps is to elicit social information and organize it spatially; while GIS does the reverse, and arranges spatial information to shed light on social phenomena. As a result, social issues appear on the left side of the figure with a dark arrow toward participatory maps, while spatial issues appear on the right connected more strongly to GIS maps. This is not to say that GIS maps are not associated with social issues or vice versa, only that both GIS and participatory maps have different dominant characteristics and influences. The central position of digital participatory mapping in the figure illustrates the flexibility of this method in balancing multiple attributes and making project-relevant (instead of technology-driven) trade-offs. Collecting participatory information using traditional methods allows the focus of the dialogue to remain on social not spatial issues, while integrating the data into the GIS formalizes the spatial characteristics and maximizes the relevance and potential for integration with other related data. Striking this balance goes back to the differences between *how* and *where* people live and brings both types of information together.

The second dimension in Figure 1 is formed by the relationship between accuracy and precision. These attributes are central to traditional map-making, and as a result, the terms have almost become interchangeable; however, the differences between the two are important, if subtle. The term accuracy, as it is used here, is intended to describe the 'correctness' of information, while precision is a description of the 'resolution' of the representation. In all cases it is important for maps to be both accurate and precise (to their respective scales and resolutions). Placing GIS maps on the right-hand side of the figure connected more strongly to precision does not imply that these maps are inaccurate. In this case, most participatory mapping efforts focus on eliciting and recording accurate social information with varying degrees of spatial precision, while GIS maps require a certain degree of spatial precision to correctly illustrate social phenomena. Ideally, all maps would be both socially and spatially accurate and socially and spatially precise; however, this dimension is particularly important because decisions about the required levels of precision or accuracy often drive how spatial data is addressed at the earliest phases of a project.

Figures 2 and 3 provide examples of these dimensions in practice. Figure 2 is a photo from a World Bank watershed project in Karnataka, India (2003) and Figure 3 is a graphic from a Map India conference presentation on urban sprawl, also in Karnataka (Sudhira et al. 2003). This pair of maps is simply included here to illustrate the basic attributes of participatory mapping and GIS along all three dimensions. The participatory map to the left captures the social features of watershed use and management within a village in Karnataka, while the map on the right describes the spatial distribution of all water bodies in the state. Similarly, the map on the left accurately depicts local social interactions with water resources (based on village consensus); however, this map does not appear to be either socially precise or spatially accurate or precise (nor is this type of mapping typically intended to be). On the other hand, the GIS map to the right is developed to be both spatially precise and accurate to

the selected scale, but the related social information is not readily available or interpretable in this representation.[3]

Figure 2. Participatory micro-watershed mapping in Karnataka, India. Map made by villagers using colored chalk on the ground (World Bank 2003).

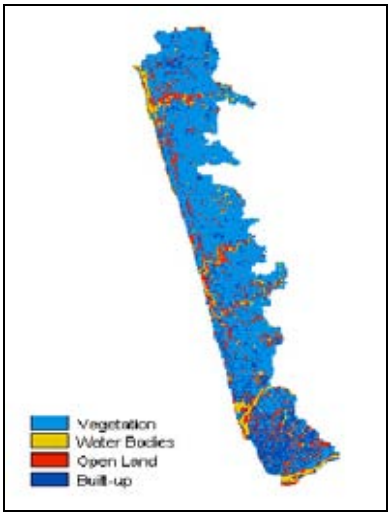


Figure 3. GIS map showing land covers and watersheds in Karnataka state, adapted from (Sudhira, Ramachandra et al. 2003).

This example brings us to the third and final dimension in Figure 1, which is based on the equilibrium between representativeness and comprehensiveness. As the maps above show, the variation along this dimension best captures the main visual differences between participatory maps and GIS maps. Participatory maps are largely subjective and focused on representing local perceptions and descriptive information. As a result, these maps are often small-scale and widely understood, like a sketch map one would use to give directions based on familiar routes and landmarks. On the other hand, GIS maps are designed to be objective depictions of reality and comprehensive sources of data, hence their visual complexity. The fundamentally different aims and applications of participatory mapping and GIS have shaped their dominant attributes. In theory, however, a collection of all possible locally representative views of a place could be assembled into a single comprehensive map, and participatory digital maps could both maintain the representative 'frames' or views provided by participatory maps while also taking advantage of the comprehensiveness provided by collective integration in GIS.

Overall, weighing the different attributes (deciding where a map should fall along each of these three dimensions) is akin to selecting the most appropriate projection for a

[3] It is very important to note that the examples here are included solely for illustrative purposes. These maps were made by different groups for different applications, and the side-by-side placement of the two is not intended to suggest that they are in any way related or comparable to one another at a detailed level of evaluation.

cartographic map. The attributes of a map that best describe a location to fit the needs of both the map-maker(s) and the map-reader(s) should drive the methods and objectives used to create the map. Stated otherwise, the trade-offs between attributes should not be driven by the limitations of the individual mapping methods, but by the needs of the project to which they are being applied. For example, mapping is currently widely used for projects including border dispute resolution, resettlement planning, and community based natural resource management. Each of these applications requires different levels of social and spatial information, accuracy and precision, and representative and comprehensive data. Defining the balance of attributes in advance of a project's implementation requires careful evaluation of the primary project and stakeholder needs. This framework is a critical tool for understanding how different mapping methods and their combinations of methods could be best applied within different scenarios, and also determining to what extent these approaches meet project needs along each dimension.

The next sections of this paper implement this framework for both planning and evaluating three different strategies for integrating participatory mapping and GIS into participatory digital mapping. Section 3 presents a sketch mapping study in several Pittsburgh area neighborhoods. This study focuses specifically on bringing the social dimensions of participatory mapping into GIS, and transforming the output of a GIS to resemble a participatory map to evaluate the relative impacts on stakeholder perception and communication. Section 4 then builds on this study to assess new techniques for map elicitation and collection, such as digital pen input, that could improve the efficiency of integrating participatory information into a GIS. Both of these studies begin with the attributes on the left sides of the dimensions in Figure 1, and bring participatory maps toward GIS maps along all three dimensions. As a counterpart to these approaches, the final study in Section 6 evaluates the interpretation of participatory digital maps by unfamiliar audiences, and shifts the focus from right to left in Figure 1 by transforming the dominant attributes of conventional GIS output to resemble participatory maps.

Understanding the 'Backyard': A Case Study of Pittsburgh Neighborhoods

Both top-down and bottom-up development planning have increasingly revolved around communities and neighborhoods. In the face of not-in-my-backyard (NIMBY) opposition to a variety of development efforts, planners and stakeholders alike now require extensive information about the objective and subjective characteristics of communities and their residents. Spatial information is essential to understanding these local priorities, perceptions, and preferences and to making socially-acceptable decisions; however, most strategies to addressing NIMBY problems have been advanced in the absence of a clear characterization of the 'backyard.' To address this gap, this first of three studies develops and evaluates a combination of participatory sketch mapping and GIS as a basis for 1) collecting local information, 2) integrating this data into GIS, and then 3) generating participatory

information from the GIS for facilitating communication and participatory decision making about individuals' neighborhoods.

Participants were recruited from several Pittsburgh community organizations to be part of a three-part study: a written survey, a mapping interview, and a follow-up evaluation interview.[4] The focus of the study as a whole was on eliciting individuals' priorities for their communities, their perceptions of their own and other adjacent communities, and their preferences for different neighborhoods and maps. Because of the scope of this work, only the aspects relevant to the discussion of mapping are included here. This section briefly describes the methods, maps, and major findings from the two interviews.

All mapping interviews were conducted on a one-on-one basis, and consisted of a semi-structured questionnaire designed to elicit a participatory map. Each map was hand-drawn using *only symbols and no text* in response to the sequence of interview questions. Respondents began by drawing a symbol for their home at the center of the page, and continued by adding their place(s) of work and other related routes and destinations. Using this format, individuals also added landmarks, places of special significance, positive and negative spaces, and other information to describe their activities and interests. All symbols were uniquely selected and drawn by each map-maker to best represent and communicate their personal associations with specific locations. Figure 4 is an example of the types of sketch map generated using this process.

[4] For more information on this study, see the working paper "Understanding the 'Backyard': Mapping Community Priorities, Perceptions, and Preferences." (Vajjhala, Fischbeck et al. 2005a).

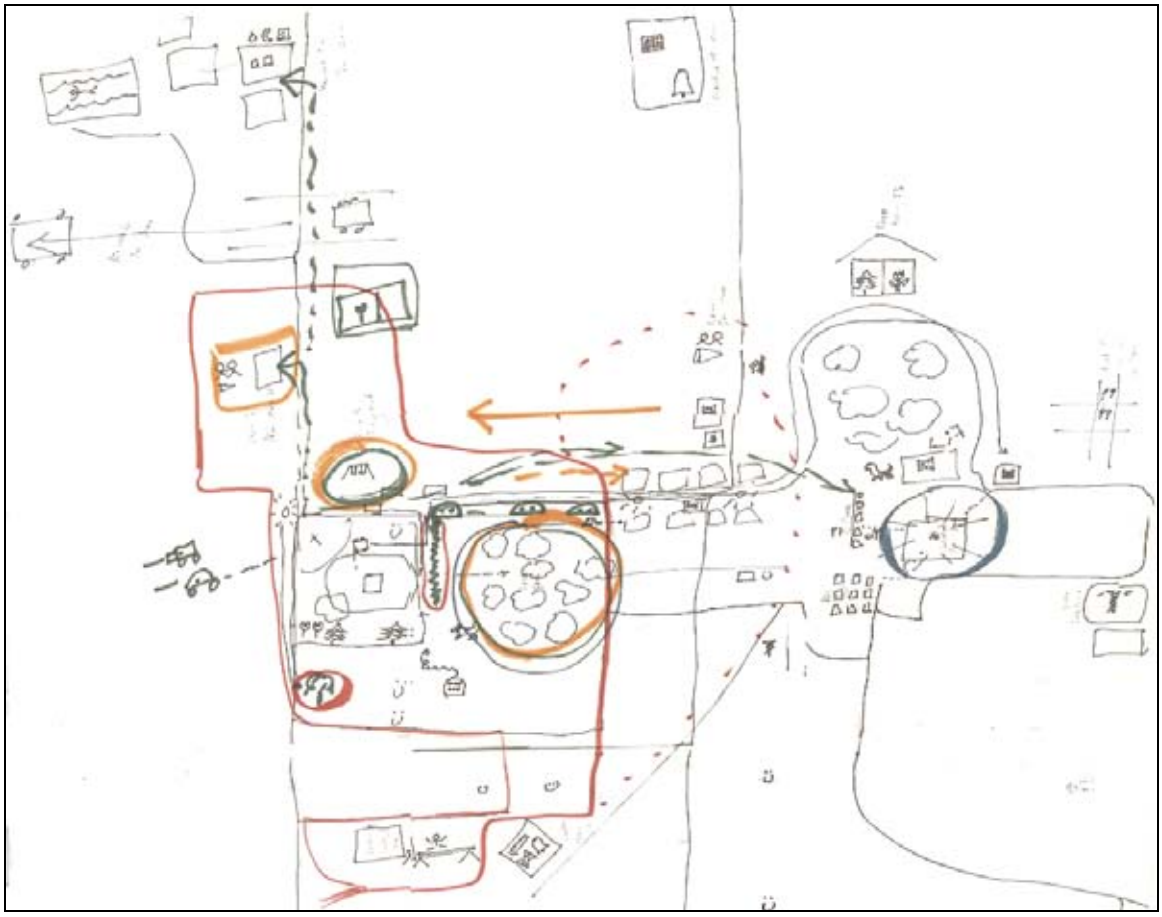
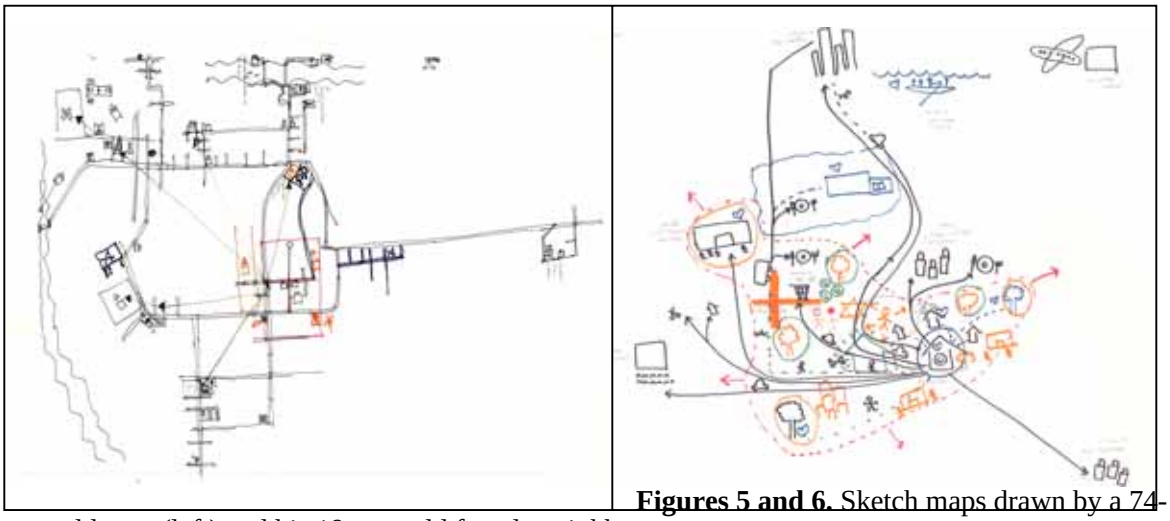


Figure 4. Part of a 48” x 60” map drawn by a female resident of a mid- to high-income urban area.

Although many participants initially expressed reservations about their drawing skills and way-finding abilities, after the interview all subjects had high levels of satisfaction with both the map-making process and their maps. As a final step in the mapping interviews, participants were asked to draw a red line around all of the places on their maps that they felt were part of their community. Figures 5 and 6, illustrate how even neighbors can have entirely different perceptions of and priorities for their shared community. The boundary of the map-maker’s community in Figure 5 includes only the 2-blocks in all directions around his home. On the other hand, his neighbor’s community in Figure 6 includes most of the places on her map. Not only does the definition of community vary among community members, these perceived boundaries do not correspond with typical, artificial boundaries such as zip codes, census tracts, or other superimposed divisions. As a result, communicating with a broad audience requires an acknowledgement of their diverse frames of reference (or backyards) within any dialogue, in order to make development decisions that are locally-relevant, well-understood, and widely-accepted.

After each respondent completed the first interview, the resulting participatory map was used to develop several additional maps in GIS. First, all of the symbols developed by each map-maker were re-drawn, collected in a new symbol library, and loaded into GIS. Next a graphic version of the original map with all of the original destinations and routes was created using these new standardized symbols (see Figure 7). Then each participatory map was also input into GIS using a process of address-matching to create as spatially accurate a representation of the participant's map as possible (see Figure 8). Point markers were added on new layers for each subject at the locations defined on the original maps. Picture icons from the symbol library were individually selected to replace the default markers on each layer. Based on this process, GIS versions of the original participatory maps were generated at two different scales, local (1"= _ mile) and regional (1"= 2 mile). The figures below illustrate the transformation from one participant's standardized graphic map (Fig. 7) to a regional-scale GIS map (Fig. 8).



Figures 5 and 6. Sketch maps drawn by a 74-year old man (left) and his 19-year old female neighbor.

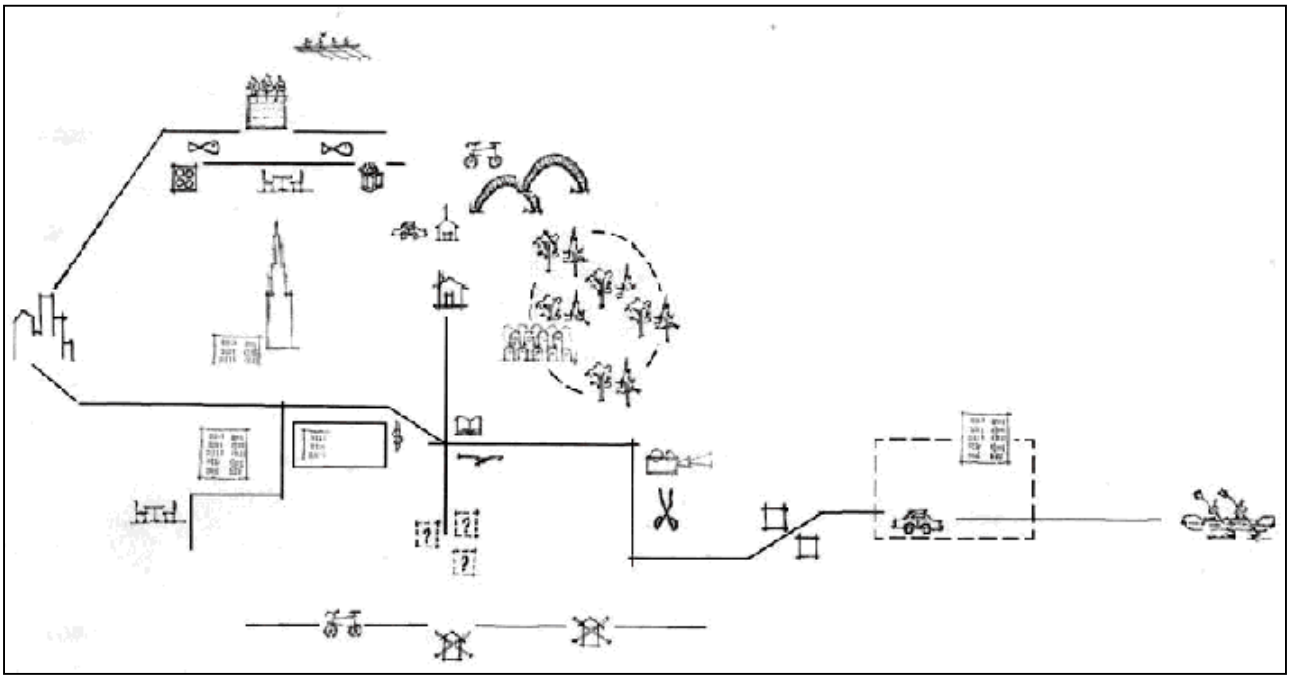


Figure 7. A standardized graphic version of a 58 year-old woman's personal scale map.

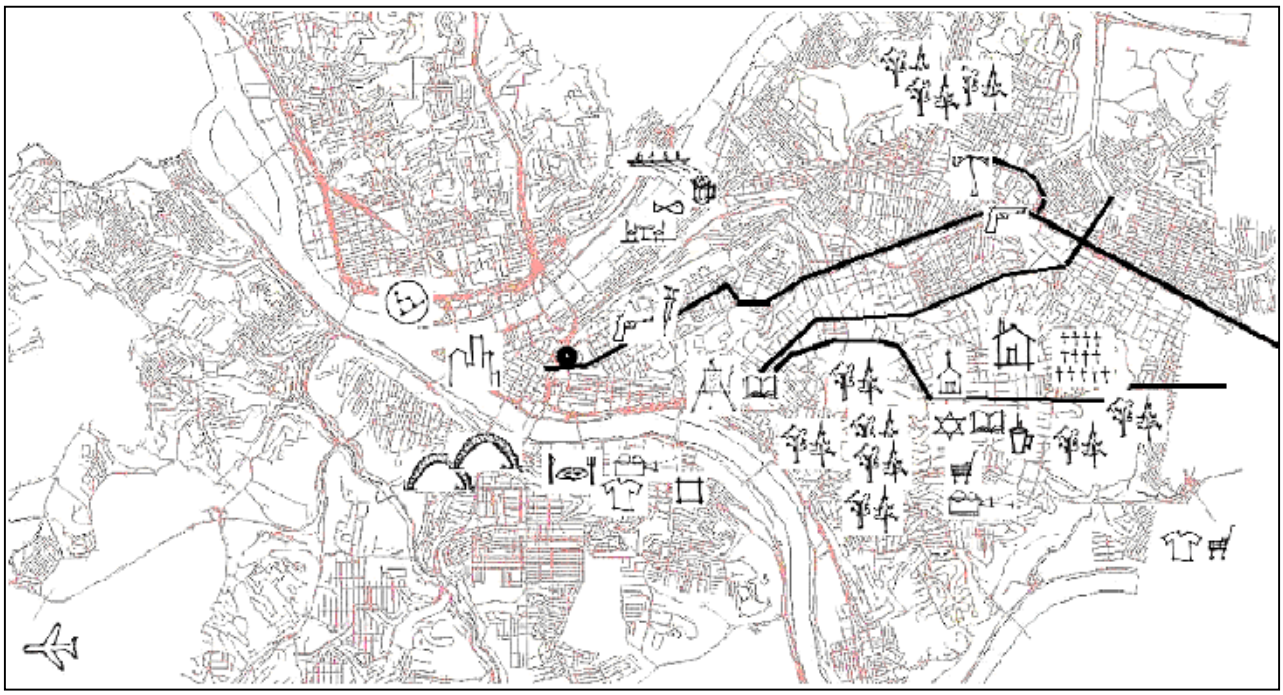


Figure 8. A GIS-version of the personal graphic map in Fig. 7 at a scale of 1"= 2 miles (not to scale)

As Figures 7 and 8 illustrate, the simple addition of familiar symbols to a GIS map, dramatically transforms the map display and integrates the social accuracy of the original participatory maps with the spatial precision of the underlying GIS layers. Also the new participatory digital maps maintain both the representativeness of the participatory data and the comprehensiveness of the GIS maps by organizing participatory information on individual layers. Unlike typical layers grouping similar features, such as schools, these new layers represent individuals or groups that describe specific sub-populations, such as women, minorities, or the elderly. These new layers act as a series of perceptual 'lenses' through which to disaggregate information, query data, and compare views of the region as a whole.[5]

This process described above transforms a GIS to generate maps based on a variety of user-defined symbols; however, the comprehensibility of participatory maps comes not only from locally-relevant symbols, but also the cognitive simplification of map scales (Tversky 1992). Throughout the process of creating their maps, participants relied on both time and distance for orientation, scaling their maps, and locating important places relative to one another. These more complex relationships between places provide a fundamental "sense of place" and allow individuals to make inferences about the "livability" of a community. For example, a place that is only one-mile away could take 25 minutes to reach by car if it is across a major river; therefore, it is important for any combination of participatory mapping and GIS to capture and represent both distance and accessibility.

In order to also address these issues of scale in the study, all participants were asked during the first interview to describe the travel times and distances to key locations on their maps by different modes of transportation. A series of time maps (see Figure 9) were then developed based on these elicited travel times for up to four modes of transportation (car, bicycle, public bus, and walking) as relevant for different participants. Each time-map is organized with the map-maker's home at the center and all other map symbols positioned along concentric rings of increasing numbers of minutes. All map symbols are located in the same cardinal-direction from the map-maker's home as on a standard distance map. In conjunction with the typical distance-scale maps, these maps illustrate both the proximity and accessibility of different locations. All of these distance- and time-scale maps and additional maps of other neighborhoods were evaluated by respondents in a follow-up session, two to three weeks after the first interview.

[5] This interview was designed specifically for one-on-one interaction with individuals and tailored to the target population in the Pittsburgh area; however, the same method could be applied in a variety of other contexts, including rural or developing world communities. The interview format here focuses generally on mapping livelihoods and could be adapted to elicit social and spatial data for a wide range of locations and populations.

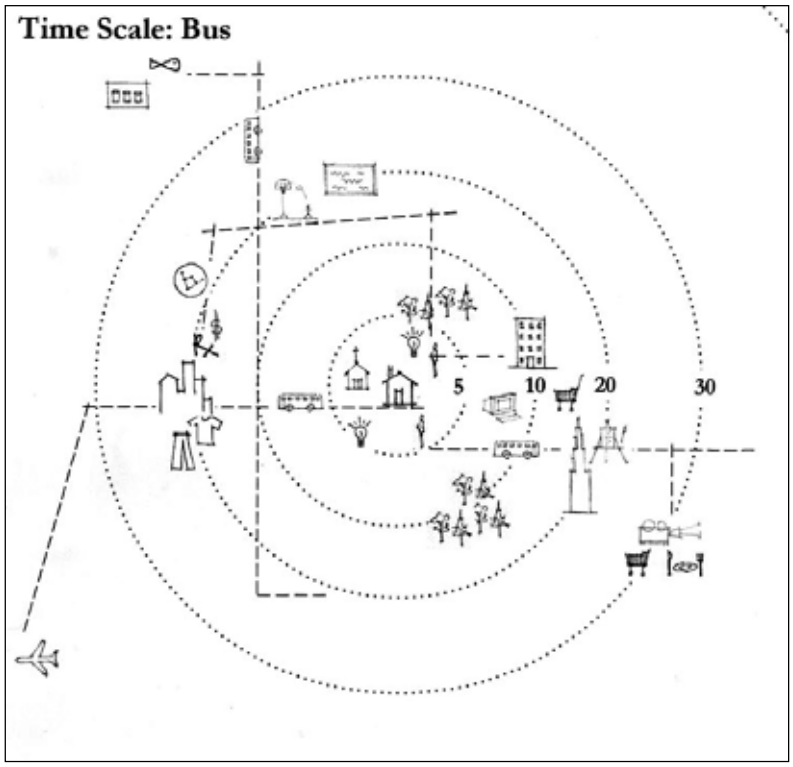


Figure 9. An illustration of a time-map developed from elicited information about travel times from home. Versions of these maps could potentially be created in GIS using path and network analysis data.

The second interview in this study was designed to evaluate participants' comprehension of different symbols, scales, and maps. This interview also assessed their preferences for two hypothetical neighborhoods, Neighborhood A, a suburban community, and Neighborhood B, an urban area. Not only were individuals highly proficient at identifying a variety of symbols, but all participants were capable of forming strong opinions about places that they had never seen before (represented by Neighborhoods A and B). After reviewing both distance and time maps for the hypothetical neighborhoods, respondents made some of the following observations:

> "Neighborhood B is too noisy; I wouldn't want to live there." - Subject 120
> "I like the 'walkability' of my neighborhood. A is too suburban."-Subject 107
> "I love Neighborhood A! It's perfect, it is just so peaceful!" - Subject 109

While traditional GIS maps convey information about a place, they do not provide a "sense of place." This fundamental "feeling" about a place usually comes from visiting that place, seeing photographs, or hearing stories, and is essential to being able to make decisions or form opinions about a place. This study establishes participatory digital mapping as a medium that connects the sense of place captured by participatory maps with more objective GIS data.

Overall, this first case study provides strong support for the potential and value of combining participatory mapping and GIS into participatory digital maps. This combination brings the major strengths of both sketch mapping and GIS together to create a flexible medium for information integration and dissemination. In spite of the effectiveness of the final digital maps, the process of collecting participatory maps and entering the information into a GIS was extremely time-consuming and as a result largely ineffective for swift information

exchange. The next two sections of this paper briefly describe and illustrate several alternatives for improving the processes of information collection and integration between participatory maps and GIS.

Mapping Alternatives: A Study of Wilkinsburg Community Priorities

As a follow-up to the mapping study described above, a community development effort based on similar participatory mapping and GIS techniques was undertaken in the adjacent city of Wilkinsburg, PA. As part of a project to include citizen input into community development planning, maps were collected from various community groups including youth camps, elementary school classes, citizen block groups, family planning organizations, and senior citizen centers.[6] Unlike the participatory maps from the Pittsburgh study, which were individual maps elicited using a standard interview protocol; these maps were collected from a mix of individuals and groups using a wide variety of participatory mapping techniques. The focus of this study was on eliciting information from groups using modified mapping techniques that were designed to simplify the collection and integration of information into a GIS.

Several different methods were evaluated during more than twenty mapping sessions across a six-month period. The most successful method at quickly and efficiently collecting participatory information involved the use of colored stickers placed on a printed GIS street map to locate and code positive places (blue), negative spaces (Sexton, Marcus et al.), and things that residents would like to change (green). Participants were provided with base maps of the Wilkinsburg area showing only the major streets, and at the beginning of each session groups were asked to place the first sticker with the symbol of their choosing at their current location. Completed maps included small-scale improvements, such as repair of a single abandoned house, to large-scale improvements, such as the construction of a community grocery store. The strength of this method was its broad appeal, especially for audiences who were otherwise resistant to drawing or developing their own maps from scratch. Additionally, these maps were collected much more quickly and easily than individual sketch maps. A single mapping session could allow multiple groups of 4-5 individuals to simultaneously add stickers to their own base maps. One major weakness of this approach was that participants who were uncomfortable with the details of the street grid were confused, frustrated, or limited by the incompatibility of their own cognitive maps with the base maps they were forced to work with. Some such individuals focused solely on familiar areas or major arteries and did not include important supporting information on their maps. In this process, these maps lost some of the accuracy and representativeness gained by the direct elicitation and address-matching used

[6] This work was completed within a larger community development program supported in parts by the Random Acts of Kindness Foundation and the Wilkinsburg Arts Initiative, and coordinated by Denys Candy at Community Partners Institute. All mapping sessions were conducted between November 2001 and June 2002.

with the original sketch maps, but the integration into GIS was only minimally affected by this loss of detail.

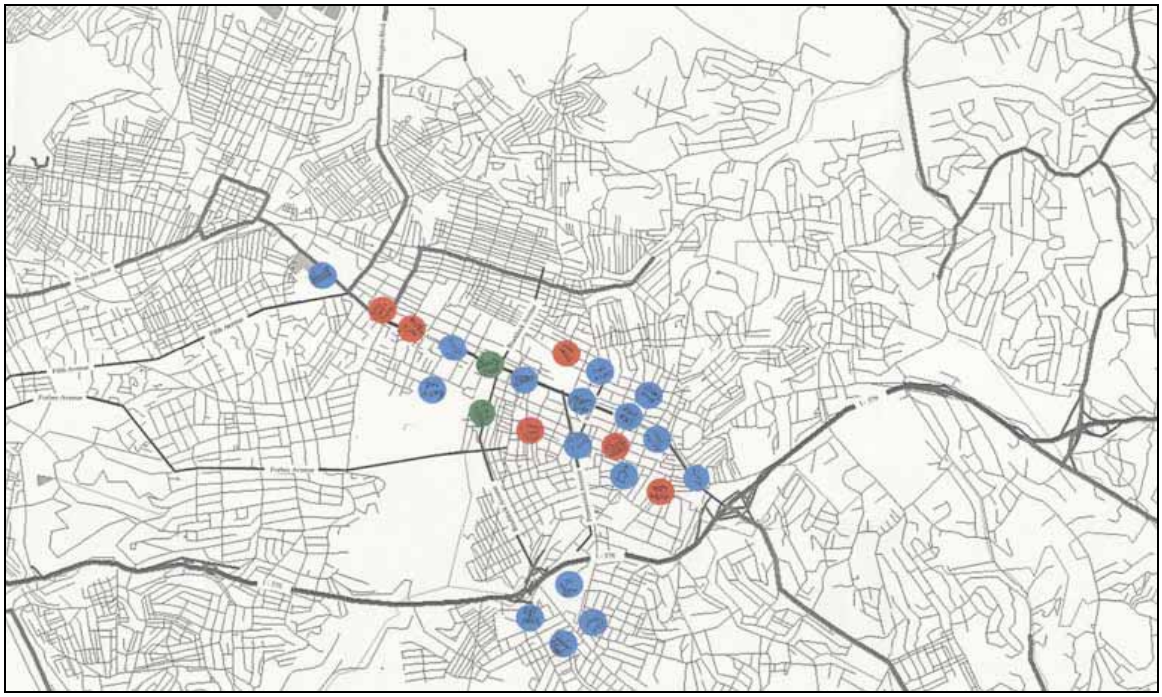


Figure 10. A printed GIS street map of Wilkinsburg with stickers and symbols added by residents.

The remaining mapping methods were all combinations of the participatory sketch mapping interviews described in the previous study and the sticker mapping approach shown in Figure 10 above. Participants in some groups drew individual maps in response to collective questions about the positive spaces, negative spaces, and places they would like to change in their communities. Other respondents developed hand-drawn group maps as collective drawings on top of printed street maps, and still others used a combination of stickers and drawings. Each of these mapping techniques had its own strengths and weaknesses for different applications and groups of map-makers. For example, participants from youth groups expressed preferences for the individual hand-drawn maps, while senior participants said they preferred the convenience and clarity of the sticker maps.

As a conclusion to this community mapping project, all individual and group maps were displayed in a community art event held in Wilkinsburg in June 2002. A large interactive map was included in the exhibit, and all visitors were provided with pens and colored stickers to add their own perceptions of the Wilkinsburg community to the gallery map. The resulting interactive maps served as feedback to the community of how their community is perceived by outsiders and placed the neighborhood in the larger context of the region. This interactive map made a step toward transforming maps from simple information displays into dynamic media for communication. The last study in this paper builds on this project to evaluate another method for improved information integration. This section also presents a final community

mapping survey designed to assess the further potential of participatory digital maps as communication and decision support tools.

Figures 11 and 12. Versions of Wilkinsburg groups' hybrid sticker maps and participatory street maps.

Extending Participation: An Evaluation of Digital Maps in the Mon Valley

As discussed above, this final study builds on the first two projects to 1) evaluate the integration of participatory maps into a mobile GIS unit using digital pen technology and 2) to assess the value of these new maps for communication and decision-making among groups who were not direct participants in the map-making processes. The first phase of this project combined two unique technologies, a Logitech io digital pen and a mobile GIS unit (HP iPaq hardware with ArcPad software), to test the hypothesis that gathering, integrating, and disseminating participatory information could be made both more efficient and more effective by inputting participatory maps directly into GIS using a digital pen. This connection could avoid the time-consuming process of digitizing hand-drawn maps or manually entering data. To evaluate this hypothesis, several participatory maps from the study described in Section 3 were 'digitized' using a digital pen. Although, the process was both successful and efficient, there were several features of the pen and its associated software that made the process less effective for certain applications than originally anticipated.

First and foremost, digital pens are still an emerging technology. Currently, most pens are bulky and restrictive, and all pens that were available at the time of this study required the use of custom "digital paper" at a maximum size of 8.5" x 11" to record any data. This posed a significant limitation to collecting or even replicating participatory maps, which often develop dynamically through group interaction and discussion, and as a result, require much larger surfaces for drawing and adding information. Nevertheless, there were two major strengths of the proposed method. First, the process of data entry and integration was easily and readily standardized. Maps drawn with the digital pen were directly and immediately downloaded from the pen for use in ArcGIS and ArcPad. These files were then available for use as images within existing map documents or as the basis for new digitized layers. Second, the maps

created with the digital pen were directly stored as digital media files. Participatory information is often very material intensive with extensive paper records of surveys, maps, and interviews. Changing the process of data gathering to direct digital input makes collected information easier to store, manage, and maintain. Based on these preliminary evaluations, it is possible that as available pen equipment improves, the technology will be better suited to the proposed method of digital information integration and the needs of diverse mapping projects and participants.

Although the technology posed some challenges, the second phase of this study built upon the digital maps created in part one to form a major written survey. Maps drawn by several residents of two urban neighborhoods were compiled along with a GIS map of the same area into survey booklets.[7] Participants for the survey were recruited from community organizations in the greater Pittsburgh region, and were randomly assigned to receive a booklet with maps of either of the two selected neighborhoods. Each booklet included sets of questions based on five separate (8" x 8") maps of a common 2 mile-square area for each of the two different neighborhoods. The first map in each booklet was a standard GIS map developed using available Pittsburgh city data. The remaining four maps were the digitally-input maps of the selected neighborhood map-makers from the original study. Figure 13 is an example of two participatory maps of the same neighborhood used in one survey booklet. Only portions of the original maps were shown within the defined square, but each participatory map included the map-maker's home and a common main intersection within the mapped area.

Each survey began with a series of questions that were repeated with each map to evaluate individuals' general comprehension of both the map and the neighborhood. A second group of questions elicited participants' understanding of each original map-maker's perceptions and priorities of his neighborhood based only on the information on the map. These questions were based on the ten neighborhood attributes from the written survey in the first study to allow for comparative analyses of neighborhood ratings with original map-makers' and neighborhood residents' ratings. The final section of the survey asked participants about their own personal preferences for different representations of information for a variety of different community development decisions and scenarios.

[7] As with the first study in Section 3, this experiment and survey are part of a larger working paper, and only the specific methods and results relevant to the discussion of mapping are presented here. For more detailed information on this study see Vajjhala, Fischbeck et al. 2005b.

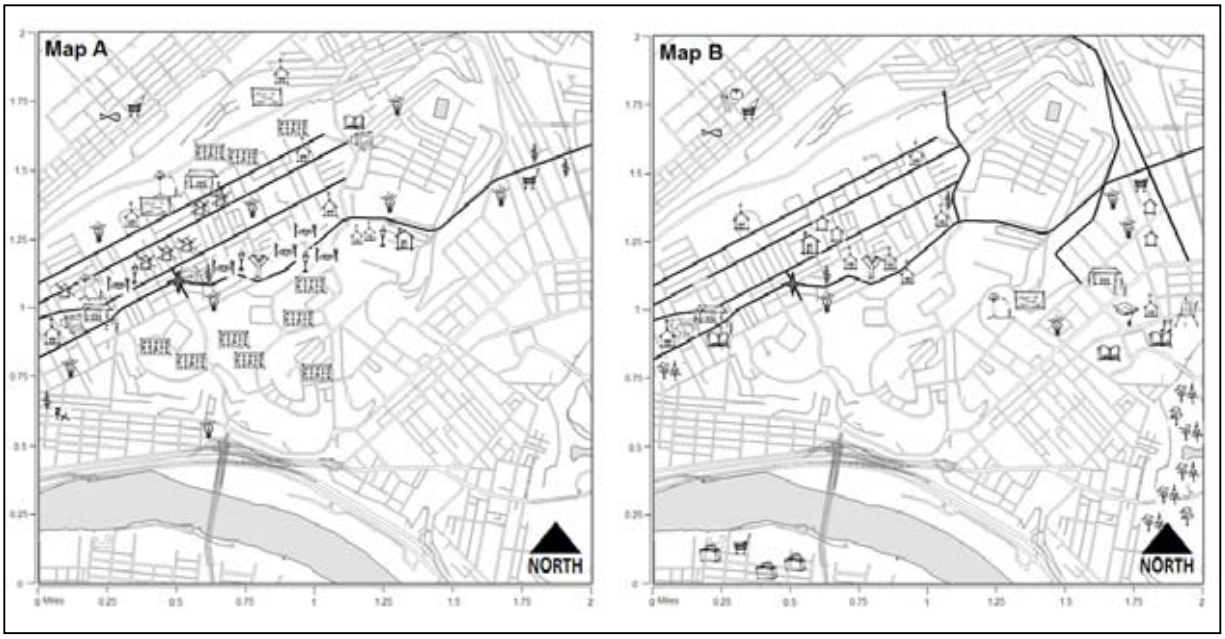


Figure 13. Participatory maps from two residents of a low-income neighborhood used in survey booklets.

The first and most basic results from the study were general tests of comprehension, map-reading, and neighborhood understanding. The majority of respondents correctly interpreted and answered the basic symbol and scale questions for both GIS and participatory maps. The most significant findings from this survey, however, are the results of relative comparisons of the original map-makers' ratings and the new map-viewers' ratings for the different maps and neighborhoods. A series of within and between subject evaluations based on the 10-attribute neighborhood ratings were compared across all five maps and the respondents' final assessments. Using a series of before-and-after ratings, the questions were designed to evaluate if and to what extent the selected participatory digital maps provide more or better information than a comparable GIS map. Comparing residents' ratings from the initial survey with the evaluations of the new respondents, who were largely unfamiliar with both the process of participatory mapping and the character of the original community, indicates to what extent the maps communicate participatory information to unfamiliar audiences.

On the whole, the results of the survey provide strong support for the participatory digital maps as communication tools. After viewing only the GIS map of each neighborhood, on average respondents rated 45% of the attributes as NA (Don't know/Not enough information). After viewing all five maps for the same neighborhood, the number of NA ratings dropped to 12%, or roughly only 1 out of 10 attributes. Similarly, after viewing only a GIS map, survey participants' ratings of the two very different communities were not significantly different; however, after reviewing the four selected digital participatory maps, respondents' ratings shifted significantly. Participants who evaluated maps of a low-income

urban neighborhood on average adjusted their ratings downward and moved toward the actual ratings by residents and the original mapmakers. Similarly, respondents who viewed maps of a mid to high-income urban neighborhood shifted their ratings upward to reflect a more positive impression of the community that also aligned with the ratings of community residents. This change in ratings clearly illustrates that the digital participatory maps in the study not only communicated additional information over conventional GIS maps, but they also accurately conveyed the original map-makers' perceptions and evaluations of their own communities.

This study provides unique insights into the role and effectiveness of digital participatory maps for outreach and extending the benefits of participation. Results show that the added value of participatory symbol-based map representations over GIS maps is two-fold. First, the "sense of place" captured by these new maps can be conveyed to an audience of indirect participants and non-map-makers. Second, these digital participatory maps communicate different types of information than comparable GIS maps. Taken as a whole, these findings build even further on the results from the first two studies to support the proposed methods and maps as tools for participatory information exchange and communication among community stakeholders and groups about shared community development decisions.

Conclusions and Discussion

This paper establishes both the theoretical and practical value of participatory digital mapping. There is no "magic bullet" for integrating GIS and participatory mapping that addresses simultaneously the needs of all map-makers and map-viewers. There are multiple strategies for collecting participatory maps, integrating the information into GIS, and generating additional maps based on the elicited participatory information. Each one involves trade-offs. The three strategies and applications testing the combination of participatory mapping and GIS proposed in this paper are in no way the only appropriate methods or approaches. This paper is simply intended to illustrate the diversity of community development planning needs which require tailored strategies to deal with complex realities and projects.

It cannot be emphasized enough that this paper is not intended to serve as a detailed "how-to" guide or instruction manual for integrating participatory mapping and GIS. Instead the aim of this work is to organize the wide range of current mapping efforts based on their important dimensions, and to establish a clear and replicable framework for thoughtfully incorporating mapping into a variety of other types of projects and applications. This framework and the related examples here seek to overcome the problems arising from arbitrarily extending tools or methods without an eye toward their inherent strengths and limitations within different contexts. This new approach is not a replacement for existing methods or types of information. The methods developed here are designed as a supplement and complement to the host of successful, established participatory techniques currently in place. This paper looks holistically at advancing a tool that can be tailored and adapted to the

dynamic needs of all of the major steps of participatory processes: information gathering and dissemination, communication, and participatory decision making.

Overall, this approach is relevant to a variety of global development efforts including: community-based design and planning, infrastructure and facilities siting, trans-boundary natural resource management, health care service delivery, development-induced displacement and resettlement, environmental justice initiatives, and border and resource conflict resolution, among other worldwide programs. All of these projects share common associations with spatial data and the need for effective stakeholder participation in planning processes. The combination of traditionally top-down GIS and bottom-up participatory mapping methods established here provides a vital link between designing and informing effective large-scale development plans to coordinating and implementing locally-relevant sustainable solutions.

References

Abbot, J., R. Chambers, et al. (1998). "Participatory GIS: Opportunity or Oxymoron?" PLA Notes **33**(5): 27-33.

Arnstein, S. R. (1969). "A Ladder of Citizen Participation." Journal of the American Planning Association **35**(4): 216-224.

Beierle, T. C. and J. Cayford (2002). Democracy in Practice: Public Participation in Environmental Decisions. Washington, D.C., Resources for the Future.

Brodnig, G. and V. Mayer-Schönberger (2000). "Bridging the Gap: The Role of Spatial Information Technologies in the Integration of Traditional Environmental Knowledge and Western Science." EJISDC **1**(1): 1-15.

Chambers, R. (1983). Rural Development: Putting the Last First. Edinburgh Gate, Pearson Education Limited.

Chambers, R. (1994). "The Origins and Practice of Participatory Rural Appraisal." World Development **22**(7): 953-969.

Chambers, R. (1997). Whose Reality Counts? Putting the First Last. London, ITDC Publishing.

Chess, C. and K. Purcell (1999). "Public Participation and the Environment: Do We Know What Works?" Environmental Science and Technology **33**(16): 2685-2692.

Coenen, F. H. J. M., D. Huitema, et al., Eds. (1998). Participation and the Quality of Environmental Decision Making. Environment and Policy. Dordrecht, The Netherlands, Kluwer Academic Publishers.

Cornwall, A. and R. Jewkes (1995). "What is Participatory Research?" Social Science Methods **41**(12): 1667-1676.

Dunn, C. E., P. J. Atkins, et al. (1997). "GIS for Development: A Contradiction in Terms?" Area **29**(2): 151-159.

Fiorino, D. J. (1990). "Citizen Participation and Environmental Risk: A Survey of Institutional Mechanisms." Science, Technology, and Human Values **15**: 226-243.

Fischer, F. (2000). Citizens, Experts, and the Environment: The Politics of Local Knowledge. Durham: Duke University Press.

Goodchild, M. F., D. M. Mark, et al. (1997). Varenius: NCGIA's Project to Advance Geographic Information Science. Proceedings of the Joint European Conference and Exhibition on Geographical Information, Vienna, Austria, Online source: http://www.ncgia.ucsb.edu/varenius/jec.html. Retrieved May 18, 2005.

Hutchinson, C. F. and J. Toledano (1993). "Guidelines for Demonstrating Geographical Information-Systems Based on Participatory Development." International Journal of Geographical Information Systems **7**(5): 453-461.

Kienberger, S., F. Steinbruch, et al. (2005). The potential of Community Mapping and Community Integrated GIS: A study in the Sofala Province, Mozambique. 10th International Conference on Information & Communication Technologies (ICT) in Urban Planning and Spatial Development and Impacts of ICT on Physical Space, Vienna University of Technology, Austria.

Mapedza, F., J. Wright, et al. (2003). "An Investigation of Land Cover Change in Mafungautsi Forest, Zimbabwe, Using GIS and Participatory Mapping." Applied Geography **12**: 1-21.

Mbile, P., A. DeGrande, et al. (2003). "Integrating Participatory Resource Mapping and Geographic Information Systems in Forest Conservation and Natural Resources Management in Cameroon: A Methodological Guide." EJISDC **14**(2): 1-11.

McCall, M. K. (2003). "Seeking good governance in participatory-GIS: A review of processes and governance dimensions in applying GIS to participatory spatial planning." Habitat International **27**: 549-573.

Renn, O., T. Webler, et al., Eds. (1995). Fairness and Competence in Citizen Participation: Evaluating Models for Environmental Discourse. Technology Risk and Society: An International Series in Risk Analysis. Dordrecht, The Netherlands, Kluwer Academic Publishers.

Robiglio, V., W. A. Mala, et al. (2003). "Mapping Landscapes: Integrating GIS and Social Science Methods to Model Human-nature Relationships in Southern Cameroon." Small-scale Forest Economics, Management and Policy **2**(2): 171-184.

Sexton, K., A. Marcus, et al., Eds. (1999). Better Environmental Decisions: Strategies for Governments, Businesses and Communities. The Minnesota Series in Environmental Decision Making. Washington D.C., Island Press.

Stiglitz, J. E. (2002). "Participation and Development: Perspectives from the Comprehensive Development Paradigm." Review of Development Economics **6**(2): 163-182.

Sudhira, H. S., T. V. Ramachandra, et al. (2003). Urban Sprawl Pattern Recognition and Modeling Using GIS. Map India Conference. Municipal GIS Proceedings. Online source: http:// www.gisdevelopment.net/application/urban/sprawl/mi03142.htm. Retrieved July 2003.

Tripathi, N. and S. Bhattarya (2004). "Integrating Indigenous Knowledge and GIS for Participatory Natural Resource Management: State-of-the-Practice." EJISDC **17**(3): 1-13.

Tversky, B. (1992). "Distortions in Cognitive Maps." Geoforum **23**(2): 131-138.

United Nations. (2000). "Millennium Development Goals." Online Source: http://www.un.org/millenniumgoals/ Retrieved May 18, 2005.

Vajjhala, S. P. and P. S. Fischbeck (2005). Unpacking Participation, Working Paper, Department of Social and Decision Sciences, Carnegie Mellon University.

Vajjhala, S. P., P. S. Fischbeck, et al. (2005a). Understanding the 'Backyard': Mapping Community Priorities, Perceptions, and Preferences. Working Paper, Carnegie Mellon University Center for the Integrated Study of the Human Dimensions of Global Change.

Vajjhala, S. P., P. S. Fischbeck, et al. (2005b). Communicating with Participatory Digital Maps, Working Paper, Department of Engineering and Public Policy, Carnegie Mellon University.

Weiner, D., T. Harris, et al. (2002). Community Participation and Geographic Information Systems. London: Taylor and Francis.

World Bank (1996). The World Bank Participation Source Book. Washington, D.C., World Bank.

World Bank. (1998). "Indigenous Knowledge for Development: A Framework for Action." Online source: http://www.worldbank.org/afr/ik/ikrept.pdf Retrieved May 31, 2005.

World Bank (2003). Karnataka Watershed Development Project. Washington, D.C., World Bank. Online source: http://www.worldbank.org. Retrieved July 2003.

WSIS. (2003). "Declaration of Principles." World Summit on the Information Society. Online source: http://www.itu.int/wsis/. Retrieved May 18, 2005.

Yapa, L. S. (1991). "Is GIS Appropriate Technology?" International Journal of Geographical Information Systems **5**(1): 41-58.