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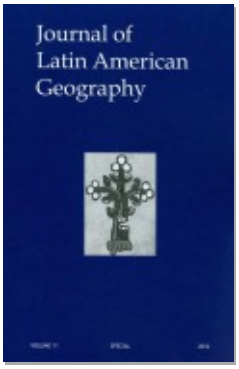

Journal of Latin American Geography, Volume 9, Number 3, 2010, pp. 111-135 (Article)

Published by Conference of Latin Americanist Geographers
DOI: 10.1353/lag.2010.0022

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Abstract
Participatory approaches to GIS make it possible for community members, scholars and GIS practitioners to document and represent complex layers of qualitative and quantitative data. However, greater attention should be paid to the socially contingent co-production of spatial knowledge that occurs in projects, and which is shaped by complex encounters between local and scientific knowledge. A critical review of the fieldwork and representations produced through a Participatory GIS (PGIS) project in Santo Domingo Norte, Dominican Republic, reveals how the dynamic engagements between community members, activists, policy makers and graduate students resulted in socially and politically informed GIS and maps.
Keywords: *Participatory GIS, service learning, critical pedagogy, Dominican Republic.*

Resumen

Un acercamiento participativo a un SIG hace posible que miembros de una comunidad, académicos y especialistas en SIG documenten y representen diferentes capas de información cualitativa y cuantitativa. Sin embargo, mayor atención se debe poner al momento de co-producción de conocimiento espacial que ocurre en los proyectos, cuando este conocimiento se modifica por los complejos encuentros entre conocimiento local y conocimiento científico. Una revisión crítica del trabajo de campo y representación de conocimiento producido por un proyecto de SIG Participativo, en Santo Domingo Norte, República Dominicana, revela cómo las dinámicas de involucramiento y compromiso entre miembros de la comunidad, activistas, representantes del gobierno local y estudiantes de postgrado resultaron en mapas y producción de un SIG enriquecidos político y socialmente por sus participantes.

Palabras clave: *SIG participativo, aprendizaje en servicio estudiantil, pedagogía crítica, República Dominicana.*

Introduction

Participatory Geographic Information Systems (PGIS) has become an important research tool for activists and scholars engaged with issues of community development, indigenous land rights, and environmental justice in Latin America and elsewhere. Conversely, by working with GIS practitioners and scholars and critically incorporating local, spatial knowledge into a digital analysis environment, marginalized communities can present alternative perspectives and interests in rhetorically powerful, spatial representations such as maps, GIS, Google Earth, and web-based mapping applications (Cinderby, Snell and Forrester 2008; Corbett and Keller 2005; Kyem 2001 [2004]; Leitner *et al.* 2002; Talen 2000; Weiner, Harris and Craig 2002). Critical approaches to PGIS also afford new opportunities for reflection and visualization of alternative futures and provide creative means to document environmental risk and other challenges faced by marginalized communities (Barndt 1998; Dunn 2007; Elwood 2002, 2006b, 2007; Ghose 2001; Kyem 2001; Talen 1999; Weiner *et al.* 1995). From a critical-pedagogical perspective, when PGIS is incorporated in experiential learning it facilitates new forms of learning through socially contextual, integrated spatial analysis among educators, students, and community members (Elwood 2009, Esnard *et al.* 2001).

However, incorporating local knowledge into GIS through such participatory processes is a highly complex technical, representational, and ethical challenge, belying assumptions that such "street science" (Corburn 2003, 2005) can easily be "translated" into a GIS format. PGIS practitioners must negotiate time, funding and data limitations and confront the structural and representational limitations of GIS, which make it impossible to mimetically represent perceptions and social constructions of landscapes and environments (Brown and Knopp 2008; Crampton 2001; Duncan and Ley ed. 1993; Harley 1988, 1989, 1990, 1992; Monmonier 1991; Pickles 2004; Rundstrom 1990, 1991, 1993). In developing countries, PGIS practitioners must grapple with institutional weaknesses, cultural and linguistic differences, uneven relations of power among community members, multiple readings and conceptualizations of landscape dynamics, and sometimes conflicting interpretations of histories and visions for imagined futures (King 2002, McCall 2003, Sheppard 2005; for critical perspectives on participatory mapping in the Global South see Fox, Suryanata and Hershock [eds.] 2005; Fox, Yonzon and N. Podger 1996; Gordon, Gurdian and Hale 2003; Offen 2003; Rocheleau 2005; Roth 2009; Hodgson and Schroeder 2002; Wainwright and Bryan 2009; Walker and Peters 2001).

In this article, we seek to contribute to this critical perspective on PGIS by focusing on the socially contingent *co-production* of knowledge that characterizes such projects. By doing so, we join critical development theorists in challenging the binary between "local" and "scientific" knowledge, which, we argue, diverts our attention from the social processes that lie at the heart of PGIS projects and leads to overly simplistic debates about issues of accuracy and authenticity. Instead, we propose that PGIS representations are products of contestations and negotiations between and among community members and practitioners, and that these social relations are informed by the complex micro-politics of the urban subaltern in Latin America and elsewhere (Scott 1985; see also Bayat 2000). We draw on the work of authors who seek to unpack the false dualism between local and scientific knowledge (Agrawal 1995, Appadurai 1995, Haraway 1991, Harding 1996, Nader 1996, Nygren 1999), but we also find inspiration from writers in the field of critical pedagogy. They posit that greater critical reflexivity (about self, others, place, and so on) is necessary in order to develop democratic partnerships with community groups and facilitate emancipatory forms of knowledge production, a perspective we seek to extend to PGIS projects (e.g. Brooks *et al.* 2002, Cook 2000, Elwood 2004, Oberhauser 2002, Roakes and Norris-Tirrell 2009). Beyond providing a critical understanding of the contingencies of teaching, learning, and doing, insights from critical pedagogy are particularly relevant for PGIS projects designed as part of a university curriculum, as in this case. Incorporating critical GIS with participatory action research in a regular university course is relatively rare, but this approach has the potential of furthering students' understanding of the social dimensions of GIS (Elwood 2009).

The PGIS project discussed here was conducted by graduate students and faculty members from The University of Texas at Austin (UT-Austin) in the informal settlement of Los Platanitos, Santo Domingo, Dominican Republic, in spring semester 2008.[1] Working closely with community members and partners in local government and non-profit organizations, students conducted a mixed-method, participatory assessment of environmental and social challenges facing the community, focusing in particular on risk and vulnerability associated with flooding. The project laid the foundation for community-based development and hazards mitigation and also resulted in a participatory model for risk and vulnerability assessment in informal settlements, available to practitioners and community members in both Spanish and English.[2] Conducted as part of a graduate course in applied GIS offered by the Program in Community and Regional Planning at UT-Austin, the class project was succeeded by a second course in spring semester 2010. This second group of students built on the work discussed here and focused on solid waste management, which had been identified as a principal public health concern and cause of flooding. In the intervening years, the Dominican NGOs Ciudad Alternativa and COPADEBA and the municipal government have developed infrastructure and housing projects in Los Platanitos based on the participatory research and analysis described here.

We begin with a brief literature review where we discuss key concepts from the critical literature on local knowledge and discuss how these can inform conceptualizations of knowledge production within critical pedagogy. This leads to an understanding of knowledge production as socially contingent, which in turn opens up possibilities for a "reflective" PGIS practice (Schön 1987)[3] that takes a more critical perspective on engagements between practitioners and community members and is more representative of the everyday realities, needs, and aspirations of marginalized communities. We then review the decentralization of urban governance in the Dominican Republic and the environmental risks confronting informal settlements in Santo Domingo, which led to the research and representational strategies used during the PGIS project in Los Platanitos.

We conclude with a few reflections about challenges and opportunities of PGIS-based research and analysis in marginalized settlements, in particular within a framework of field-based, critical pedagogy.

Knowledge Production, Critical Pedagogy, and PGIS

Our perspective on PGIS is premised on an understanding of knowledge as neither exclusively "local" or "experiential," nor exclusively "global" or "scientific." We find inspiration in critical development studies and the literature on indigenous knowledge, as well as from feminist interventions in science studies, which emphasize the social contingencies of knowledge production and problematize the presumed dichotomy between "local" and "scientific" knowledge (Agrawal 1995, Appadurai 1995, Haraway 1991, Harding 1996, Nader 1996, Nygren 1999). Local knowledge is often assumed to be merely common-sensical and derived purely from everyday, experiential practices, while scientific knowledge is presumed to derive from systematic and rigorous testing. Even though Western science is also shaped by the social and political-economic contexts in which it is produced (Bebbington 1993, Myer 1998), these narratives of objectivity lead to the fixing of Science as a "hegemonic (category) in the popular imagination" (Nader 1996, Purcell 1998). Instead, "knowledges" should be understood as contested, heterogeneous, and hybrid social constructions (Gupta 1998), produced through tangled webs of "situated and interrelated knowledges and practices, all of which are simultaneously local and global" (Moore, 1996: 9; see also Nygren 1999: 282, Robbins 2000).

This constructivist perspective on knowledge production is particularly relevant for critical approaches to PGIS, and a critical perspective on GIS more broadly. The emergence of PGIS stems in part from the development of the field of "critical GIS" in the mid-1990s, which in turn emerged from a concern, influenced by critical theory, that the positivist and quantitative approaches to geographic research inherent in GIS would circumscribe "geography's ability to make sense of the world" (Sheppard 2005: 7; see also Chrisman 2005; Harvey, Kwan and Pavlovskaya 2005; Pickles 1995 [ed.], 2004). Instead, PGIS aims to foster emancipatory and empowering GIS applications that incorporate diverse knowledges through participatory processes (Corbett and Keller 2005: 92; Dunn 2007; Elwood 2006a, 2007; Kyem 2001 [2004]; see also Sieber 2000). By their very nature, therefore, PGIS projects engender socially contingent processes of knowledge production through the intense encounters among community members and external agents such as NGOs, government representatives, and scholars situated in different organizational contexts (Elwood and Ghose 2001). In turn, such participatory processes of knowledge production are informed by complex engagements between quantitative methods and local knowledges, and shaped and disturbed by negotiations and associations between participants who operate in "spaces of dependence" characterized, in part, by differential access to resources and hierarchies of race, class, gender, and ethnicity (Elwood 2007; also Brown and Knopp 2008: 44, Elwood 2006a: 199). This means that the production of spatial knowledge in such encounters is inevitably shaped by socially constructed hierarchies of knowledge, especially the persistent dualism between presumed experiential, local epistemologies, and a presumed monolithic, and objective, scientific way of learning.

Because PGIS operates in such a politically charged space, therefore, it is necessary to develop a theory of praxis that accounts for disparities in power between local and global knowledge systems. This is especially true for PGIS work that takes place in the Global South, where asymmetries in knowledge production are even more severe and "empowerment" is a much talked-about, but often poorly defined and elusive

goal (Corbett and Keller 2005; Kyem 2001 [2004]). Specifically we ask, how can PGIS be approached in ways that are reflective and critical of such hierarchies implicit in knowledge production, and at the same time, facilitate democratic productions of spatial knowledge and lead to representations that in turn effect a more just distribution of economic and political resources? In short, how can a critical approach to knowledge production within PGIS serve what Merrett (2000) calls geography's "neglected tradition" of social justice (see also Fuller and Kitchin [eds.] 2004; Heyman 2001a, b; Heyman 2007; Maxey 1999), while at the same time facilitating geographic knowledge production in participatory, emancipatory spaces outside the "academic lifeworld" (Sheppard 2005: 15)?

To encourage such critical approaches to knowledge production in PGIS, we find it useful to engage with debates on the social contingencies of knowledge production developed in the literature on critical pedagogy and reflective approaches to service learning. Service learning is premised on developing close working relationships with community members and activist groups, where students learn research methods and develop topical knowledge while contributing technical expertise to community partners (Brooks *et al.* 2002; Harris 2004; Kent, Gilbertson and Hunt 1997; Lemieux and Allen 2007; Schweitzer, Howard and Doran 2008). However, such service learning projects should challenge students to reflect on their positionality and the possible, social and political consequences of their engagements with less-privileged communities (Boyle-Baise 1998, Boyle-Baise and Sleeter 2000, Heyman 2001b, King 2004, Wade 1997). At each stage of such critically informed service learning projects, students should critically consider how their privileged position as keepers of "expert" or "professional" knowledge shapes their approach towards the experiential, local, (and often dismissed) knowledge of community members.

This is because knowledge production in such service learning projects is never straightforward, but instead shaped by the politically and socially charged encounters between people who bring their own positionalities and their own assumptions about place, people, and the relative value of different forms of knowledge to the project. Students must be challenged to break with the scientific tradition of knowledge production through observation, data collection, laboratory analysis and so on, and instead promote a more equal exchange of ideas, knowledge and experience (Heyman 2001b, King, 2004). However, since field experiences do not in and by themselves "unproblematically enhance students' capacities to analyze [the] complicated 'fields' they experience critically" (Elwood 2004: 54), students must learn to critically consider the social constructions that inform the co-production of knowledge, which necessitates critical reflections of the very process of knowledge production (Elwood 2009).

From the perspective of critical pedagogy, such critical awareness of the social contingencies and implications of knowledge production begins with "critical reflection" about place, self, and others (Asher 2005, Brooks *et al.* 2002, Cook 2000, Maxey 1999, Oberhauser 2002, Roakes and Norris-Tirrell 2009). This presumes that learning is a dialogic process of knowledge production (Freire 1970, Webb, Allen and Walker 2002) and that "[teaching] and learning are dynamic, challenging, unpredictable, and sometimes indistinguishable, processes" (Cook 2000: 16). In turn, such a cooperative approach to learning (Merrett 2000) creates possibilities for developing an "empathic awareness of others" (Kitchin 1999: 45) and facilitates a deeper understanding of the complex social relations in which students and project participants are situated. In this way, the critical-pedagogical classroom can facilitate more just social action instead of reproducing dominant social relations (Howitt 2001: 148, see also Crabtree and Sapp 2003; Freire 1970; Giroux 1983, 1988, 1997; McLaren 1998).

Such an understanding of knowledge as *co-produced* through encounters in the field has important implications for critical PGIS. By encouraging greater reflection about our own and others' positionalities and roles in such knowledge production, this critical perspective facilitates new ways of thinking about the complex and socially contingent ways knowledge is *always* produced. In the case of PGIS, researchers must critically consider the implications of integrating local spatialities into "scientific" spatial representations such as maps and GIS, which, by their very nature, tend to fix and reduce complex, constructed, and socially contingent local spatialities (Brown and Knopp 2008; Corbett and Keller 2005; Fischer 2000; Sletto 2009a, b; Watson 2003; Umemoto 2001; see also Corburn 2003, Cole and Foster 2001, DiChiro 1998 for further discussion of this dilemma in environmental justice research).

In the project discussed here, students had the unusual opportunity to directly engage in such socially contingent co-production of knowledge, broadening their understanding of the social dimensions of GIS and developing a more critical perspective on development projects (Elwood 2009, Esnard *et al.* 2001). They worked closely with community members on "uncommon ground," understood as the space where activists and other outsiders interact with members of communities in ways that "are emotionally laden, relational, hybrid, corporeal and contingent.... [In these encounters,] questions arise such as what roles do we adopt in protest situations, what are our emotional responses, and how can we go beyond pre-determined identities and problematize our positionalities?" (Chatterton 2006: 260). To critically reflect on and share their perspectives on these encounters, students participated in daily debriefing sessions, in interviews by the documentary film maker who accompanied the students in the field,[4] and in ongoing, daily conversations with community members about research goals, data limitations, and possible future projects.

By entering into and reflecting on these encounters on "uncommon ground," the traditional division between "student," "professor" and "community member" began to diminish. This gave students a deeper appreciation of the social and technical complexities of researching and representing local knowledge via GIS (Elwood 2009: 54), and through the "creative alliance" (*Ibid.*) forged between students and community members, space was opened for community members to strengthen their ability to engage more successfully with external actors in Santo Domingo and beyond (Kyem 2001). Further discussion about the possible empowerment of residents is beyond the scope of this essay, partly because "community empowerment" is difficult to evaluate (*Ibid.*) and the project is still in its early stages. However, these critical perspectives on the social contingencies of knowledge production and the emancipatory potentials of participatory GIS was an important inspiration as the students developed their field mapping methods, partly in close collaboration with residents, and even more so when they reflected on their mapping and GIS strategies almost two years following the project.

Environmental Risk and Vulnerability in Santo Domingo, Dominican Republic

Los Platanitos is an informal settlement located in the municipality of Santo Domingo Norte on the northern edge of the Santo Domingo metropolitan area (Figure 1). With a population of approximately 257,000, Santo Domingo Norte is one of eight municipalities formed when the capital city was divided during a decentralization process begun in the early 2000s. Santo Domingo, which had a population of 2.5 million in 2001 (the date of the latest census), was originally established at the mouth of the Río Ozama in 1502 and lays claim to being the first Spanish city in the Americas. The city

grew exponentially during the late 20th century, when in-migration from the countryside combined with natural population growth led to uncontrolled development of peri-urban slum settlements (CONAU 2007, Fernández (ed.) 1996, Romero 1996).

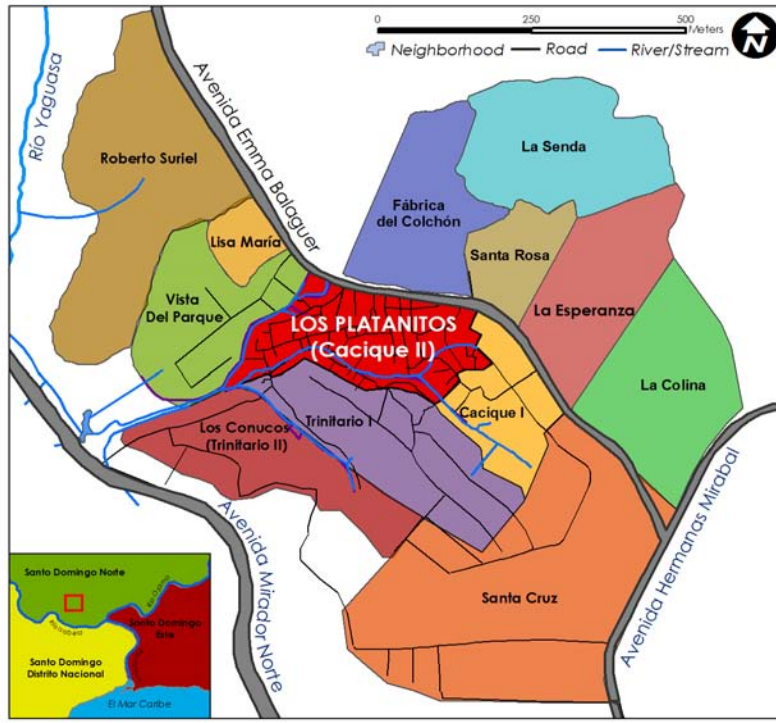

Figure 1. Los Platanitos, Santo Domingo Norte, Dominican Republic, with surrounding neighborhoods and major streets.
Map developed by Shawn Strange, Martin Thomen and Solange Muñoz (Sources: CONAU, GoogleEarth and the Community of Los Platanitos).

These informal settlements typically formed in marginal and hazardous public-use areas, including the floodplain, riverine cliffs, and canyons that drain into the rivers Ozama and Isabela. Because of their precarious location, these settlements are at risk of flooding and mudslides, which again is exacerbated by extensive development of impermeable surfaces and dense patterns of often inadequately constructed homes. As in the case of informal settlements elsewhere in Latin America, sewage, water, electricity, and solid waste services are intermittent or wholly absent, garbage accumulates in the streets and sewage drains untreated into creeks, and as a result, respiratory and intestinal diseases are common. In this, Los Platanitos fits the pattern of informal settlements elsewhere: an estimated 90 percent of Latin America's sewage is dumped untreated in streams and rivers (Davis 2006: 137). These public health challenges are compounded by high levels of crime, illiteracy, and unemployment, leaving residents exceedingly vulnerable in the face of heavy rainfall and hurricanes (Chantada 1996; Navarro 2005, 2006; Santada 2004; Tejeda 2000).

Informal settlements such as Los Platanitos have developed in large part because of the rapid in-migration to metropolitan areas during the latter half of the 20th century, coupled with the limited capacity of the state to provide adequate infrastructure and housing. On the fringes of many Latin American cities, it is increasingly common to find shanty towns and new rural migrants next to walled suburbs and middle-class commuters fleeing crime and insecurity in the city center (Davis 2006: 47). On a global level, the rapid rate of urbanization is resulting in the creation or expansion of such settlement types in the developing world (Awusu, Agyei-Mensah and Lund 2008). In 2001, 924 million people, or 31.6 percent of the world's urban poor, lived in slums (UN Habitat 2003). By 2030, an estimated 5 billion of the worlds 8.1 billion people will live in cities and about 2 billion of them will live in slums, primarily in Africa and Asia (Davis 2006, Eaves 2007, UN Habitat 2003). Urbanization is now the predominant experience in underdeveloped nations of the southern hemisphere (Davis 2006, De Soto 2000).

In many ways, Los Platanitos typifies informal settlements in Santo Domingo. The community is located in a steep canyon draining into Río Ozama and residents suffer from illnesses stemming from the open sewage, contaminated tap water, accumulation of garbage, and frequent flooding (Figure 2). Because of these precarious conditions, Los Platanitos and other communities like it are known as cañadas, a moniker that refers not only to the streams and the rugged topography

Figure 2. The informal settlement of Los Platanitos lies in a steep valley (*cañada*) and homes are at risk of flooding during heavy rains. Photo: Rosa Donoso.

but also encapsulates the precariousness of life in these informal settlements. More unusually, Los Platanitos was informally constructed beginning in the 1980s on top of a landfill; today, erosion causes garbage to emerge from the ground on the steep sides of the valley. Los Platanitos is also characterized by a strong sense of community, however, and extensive social networks provide support to families in need. Like civil

society organizations elsewhere in the Dominican Republic, informal neighborhood organizations have a history of applying constant pressure on local governments to provide basic infrastructure improvements and public services (Navarro and Mercedes 2006, Pelling 2002, Rauber 1995, Sletto (ed.) 2008).

These social networks and neighborhood organizations formed the basis for the UT-Austin PGIS project in spring 2008. Although UT-Austin's work in the Dominican Republic originated from an invitation by the municipality of Santo Domingo Norte, the PGIS project in Los Platanitos was developed as a service-learning effort in close collaboration with community organizations and with the advice and technical assistance of the municipality and the NGOs Ciudad Alternativa and COPADEBA. The goal was to work closely with community members to conduct a risk and vulnerability assessment, focusing especially on the flooding in the lower reaches of Los Platanitos. Since vulnerability is a consequence of potential exposure to hazard (in this case, flooding and garbage accumulation) combined with a lack of social capital (low levels of education, high levels of poverty, and so on), the research would require multiple methods and range across multiple scales.

During the first fieldwork period in January, 2008, students worked with community members to model the built environment and map building footprints, flood zones, and transportation networks, and conducted household surveys and interviews to identify areas and populations of greatest risk. Upon returning to Texas, students incorporated the field maps and AutoCad data with the household survey into a GIS, both in 2D and 3D, which allowed them to analyze spatial distributions of social and environmental characteristics (see Lemma, Sliuzas and Kuffer 2006 for PGIS in slums in Ethiopia). During the second research trip, in March 2008, the students delivered a report and large-scale poster to community members and project partners and also conducted a participatory problem assessment, using maps derived from the field research in January. In the following section, we present some of the principal tasks and methods used by the students who worked on the mapping and physical survey components of the project. We discuss (1) the mapping of community boundaries, (2) the mapping of urban structure, (3) the physical survey and subsequent participatory problem assessment, and (4) map symbolization and design strategies.

PGIS in Los Platanitos, Santo Domingo: Methods, Challenges and Dilemmas

Mapping community boundaries

Before the first research trip, students were tasked with producing reliable base maps to use during fieldwork. Since the spatial and aerial data acquired from the municipal government was not detailed or recent enough, the students captured a screenshot of the community in Google Earth and georeferenced this to "shapefiles" (spatial data files used in ArcGIS) of major roads provided by the municipal government. To make it easier to spatially reference locations in the field, students printed out poster-sized aerial images of the neighborhood at different scales. One image encompassed Los Platanitos and the surrounding area, another included only Los Platanitos, and a third set represented different sections of the community at a larger scale. Next, students superimposed a grid on the image of Los Platanitos and created "map books" where each page showed one of the gridded tiles at an even larger scale (approximately 1:25). In the field, students conducting the physical survey used the map books to ensure their drawings could be accurately georeferenced and student members in the GIS/mapping team used them to record hydrographic information, building footprints, and public and

commercial spaces. Students also recorded information on data sheets that were later used to populate attribute tables in GIS.

By conducting the field-mapping together with community members, students were able to record local knowledge that was not readily apparent, such as the informal boundaries of the community.v On the first day of fieldwork in January, a group of self-selected community leaders participated in a mental mapping workshop where they sketched the boundaries of the community on a large Google Earth aerial image. Following the workshop, the students and community members field-checked the mental map by systematically walking the entire extent of the community, openly discussing the boundaries among themselves and with residents who live in the immediate vicinity. Afterwards, the neighborhood boundaries were vetted again by other community members, who explained in detail the informal neighborhood divisions that make up the area. During the last days of the field research, some of the community members questioned the boundaries, which highlighted to the students the ethical and political risks of presumably straightforward cartographic acts and the complexities of political interests and power structures in Santo Domingo Norte (see Kyem 2001 [2004]).

Although Los Platanitos is not a formal political division in Santo Domingo Norte, community members realized that drawing the informal boundaries of the neighborhood carried great symbolic significance (see Figure 1 for the boundary of Los Platanitos and surrounding neighborhoods). Prior to this mapping project, Los Platanitos was not included on official maps of Santo Domingo Norte; hence community members refer to the neighborhood as the *Rincón de los Olvidados* ("the corner of the forgotten ones"). The documentation of the boundaries of Los Platanitos also offers potential political benefits to the community, including formal recognition of the neighborhood by state and municipal government officials. With such formal recognition, the neighborhood is better positioned to compete with other, planned neighborhoods in the surrounding area for municipal resources and services.

At the same time, however, students carefully considered how the drawing of boundaries of Los Platanitos could potentially reinforce or reshape relations of power, especially since their maps would bestow greater legitimacy to this particular community. By mapping Los Platanitos, one of four informal neighborhoods that make up this area, would they establish a new, spatial and social hierarchy by prioritizing one neighborhood over others? The potential ramifications of these spatial and temporal choices were not clear to the students at the time. In retrospect, they learned that their work led to the municipality to pave certain roads inside Los Platanitos, but not in surrounding neighborhoods.

In addition to their concerns about the relationships among the neighborhoods in the area, the students also considered how the complex social relations inside Los Platanitos—uneven relations of power between families, firmly established gender roles, and generational divides—might shape participation in the project and the content of the final maps (Elwood 2006a). They also began to realize the limitations of PGIS in revealing subjectivities and meaning (Brown and Knopp 2008), especially when they attempted to map flood levels along the canal in the lower reaches of the community. To develop the flood maps, students walked with elders along the length of the canal. After conferring with residents in each location, the elders indicated the highest flood stage in living memory on the exterior walls of houses or on the sides of the canyon. Although this allowed for subsequent digitizing of an approximate floodplain, the.GIS could not represent painful memories of catastrophic flooding events and the emotional toll of recurrent, minor flooding, which regularly sweeps debris and sewage into people's homes.

Mapping urban structure

As students were pursuing this co-production of spatial knowledge with self-selected community members, they also wrestled with the tensions and hierarchical relationship between scientific and local knowledge. Through their formal GIS education, they had been "disciplined" to measure quality of GIS output in terms of spatial accuracy and precision. However, these standards proved to be difficult to live up to, given the time and funding limitations of this project. Also, students were confronted with fundamentally different urban forms and conceptualizations of public and private space, which made it particularly challenging to record building footprints and the street and alley networks. In Los Platanitos, home construction is intermittent, informal, and contingent on available space and materials and social relations: homes are built wall-to-wall to save on space and materials, additions are built to add living space to a relative's family, family members frequently move from one house to another. Patios and open spaces between the densely built houses are alive with socializing, game-playing, and other activities that in the USA usually take place in "private" space. Alleys and streets are not clearly delineated from private spaces and vary in configuration, paving, and so on, creating a profoundly different urban form that requires creative mapping approaches.

Eventually, after crisscrossing Los Platanitos with the guidance and assistance of community members, students became familiar with this unusual (to them) urban structure. By systematically walking through the community with the aerial images and local guides, they were able to trace the streets and the meandering, smaller alleys and also map commercial buildings and public spaces. To develop their building "footprint" map, students traced buildings directly onto the aerial images in the map-books from the vantage points of rooftops and hills surrounding Los Platanitos. This was complicated by the haphazard building patterns that make it difficult to distinguish one building from the next, and some buildings are set behind walls of sheet metal or hidden from view behind other buildings and trees. Also, each rooftop does not necessarily correspond to a single household, making it impossible to use the building footprint data for demographic analysis. However, when the students returned in March, they were able to revise their draft maps, including the names and locations of non-residential structures, public places, and streets and alleyways, and improve their accuracy (Figure 3).

Physical survey and participatory problem assessment

An important goal of the project was to conduct participatory risk assessments workshops, and to later georeference and represent this local knowledge as a qualitative layer in GIS; i.e. coupling GIS with ethnographic methods to enhance residents' and policy makers' understanding of the challenges posed by environmental hazards in Los Platanitos (see Matthews, Detwiler and Burton 2005). This required a detailed, georeferenced spatial model of the channel and the built environment, which again necessitated a physical field survey. A team of students and community members took measurements of the channel and adjacent buildings while drawing sketches at scale by hand, and also recorded height and width of buildings and construction materials used for the walls, roof, and floors. Once back in Texas, the hand drawings were translated into a two dimensional AutoCAD site plan and the construction materials data were tabulated in Excel. The AutoCAD drawing, with its two main layers of information—the channel and the houses located next to it—was later exported, joined with the Excel file, and georeferenced in GIS to shapefiles produced by the mapping team.

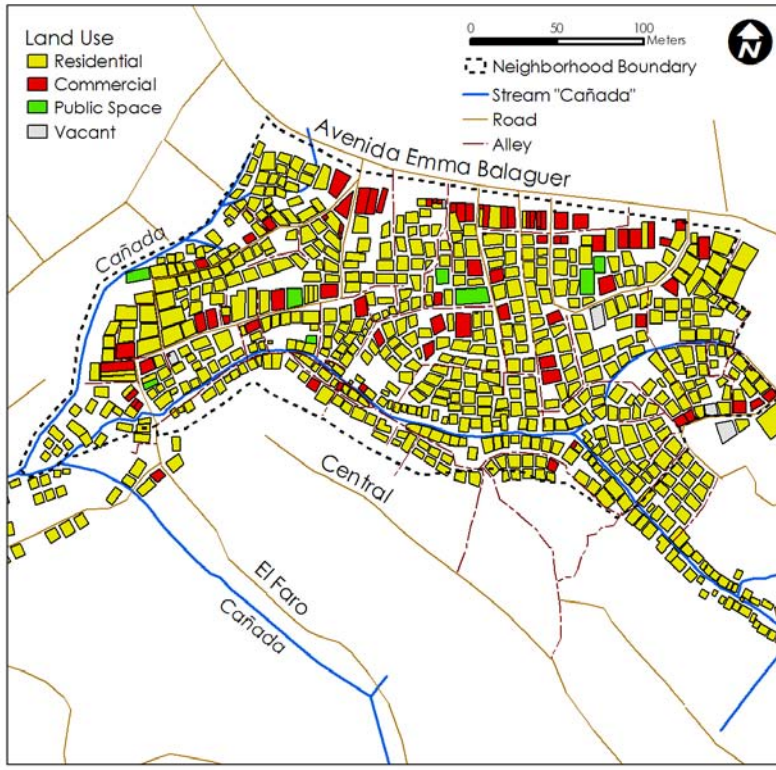

Figure 3. streets and landuse in Los Platanitos.
Map developed by Shawn Strange, Martin Thomen and Solange Muñoz
(Sources: CONAU, GoogleEarth and the Community of Los Platanitos).

The site plan showed that the channel is not homogenous—it varies in depth, width and type of structural intervention, channelizing, and so on—and that therefore, rainfall and garbage accumulation will affect the families living adjacent to it in different ways. This called for further, qualitative research with community members, since only they could provide the detailed, local knowledge to make such fine-grained risk mapping possible. When the students returned to the community in March, they held three problem evaluation workshops with groups of children, women and men separately to allow them to discuss and map what they felt were problematic sections of the channel. The workshops were conducted using posters that included the AutoCad file, the aerial image, and photographs, which allowed the students and community members to record and georeference local knowledge without walking through the actual site. In other words, the posters had to be easy for community members to read, but at the same time, sufficiently accurate to allow for effective co-production of spatial knowledge (Figure 4).

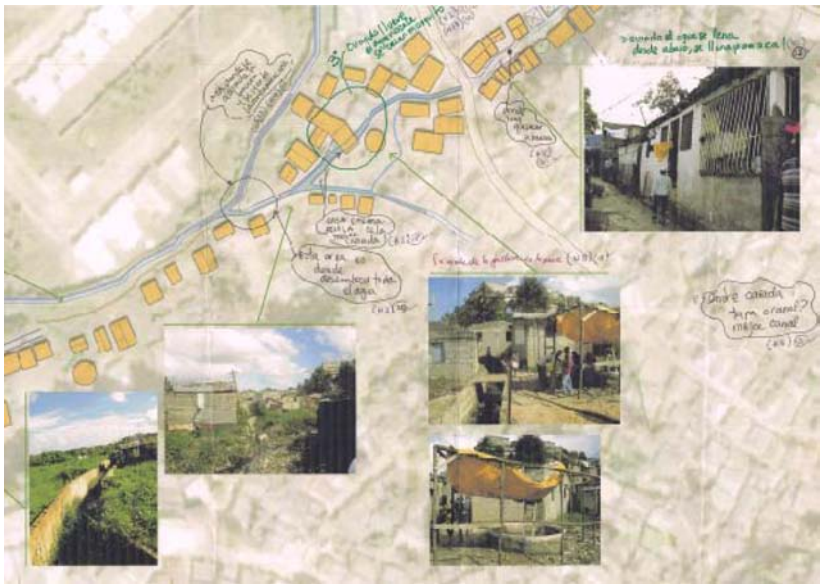

Figure 4. The AutoCad file of the built environment was georeferenced, joined to attribute tables in ArcGIS, and combined with photographs to create a poster for participatory problem assessment. This figure shows a section of the poster following the series of workshops in Los Platanitos. Design: Rosa Donoso.

To facilitate the problem evaluation workshops, students presented a series of five questions to residents. These questions had emerged from the physical survey activities during the January field research, when community participants repeated specific concerns associated with flooding and garbage accumulations. The goal of the problem evaluation workshop, therefore, was to map locations that corresponded to the concerns identified by residents. These locations included: 1) Points of trash accumulation; 2) Points of heavy flooding during rain storms; 3) Points of perceived contamination; 4) Points of perceived danger to children, and 5) Points where children like to play.

In each of the workshops, students posed these questions to the approximately 15 participants who were asked a series of questions while students recorded their answer directly onto the poster. The local knowledge recorded in the workshops was eventually tabulated in Excel and georeferenced in GIS, using the channel and house AutoCad file as reference, thus providing a layer of qualitative data superimposed on the empirical information gathered in the field.

These workshops underscored to the students and community participants that different sections of the channel are affected by different problems. Following these three workshops, students and a facilitator from Ciudad Alternativa, organized a meeting of about 10 adult men and women to rank the "most critical" areas along the channel. The goal was to openly discuss and reach consensus about the spatial variability of risk and vulnerability along the channel. Although participants eventually agreed that more extensive involvement by the rest of the community was required to come to any sort of resolution, the participatory approach helped raise awareness about the need for open

dialogue and consensus building. The PGIS process also revealed—both to community members and students—the powerful role of GIS-based spatial narratives coupled with ethnographic methods in prioritizing community needs and advocating for infrastructure improvements (Elwood 2006b; Matthews, Detwiler and Burton 2005).

Dilemmas of map symbolization and design

After returning to Texas following the January field work, students began to digitize shapefiles, record attribute data, and design the final maps. At first, this seemed relatively straightforward. The students were able to choose map symbols common in Dominican maps for features documented in the field, such as roads (represented by black lines), building footprints (salmon-colored polygons), and flood zones (semi-transparent blue polygons). But in order to represent qualitative data, they were forced to make important, politically and ethically charged decisions. The maps would be provided both to policy makers and community members, which meant choosing colors, line weight, fonts, and symbols that would appear sufficiently "scientific" to policy makers, but that at the same time would faithfully reflect local knowledge, perspectives, and interests. Also, time and funding were limited and the students would not be able to test and evaluate the legibility of their symbolization scheme with community members.

At this stage in the co-production of knowledge, then, the hierarchies of local and scientific knowledge came to the fore, as they will in PGIS projects. Map symbols carry meanings that might go beyond, or even contradict, the intentions of the map maker, making it possible to "lie with maps" or to misrepresent the meanings intended by community members, or even more fatally, represent communities in ways that might be disempowering to residents (Brown and Knopp 2008; Monmonier 1991; Wood 1992, 1993). In Latin America, indigenous homelands have been represented in maps as empty and ripe for development; conversely, through the mapping of squatter settlements, communities have been made "visible" to the state and therefore faced greater external control and violence. On the other hand, community-based mapping that draws on the languages of Western science have produced rhetorically powerful, alternative spatial representations (see Fox, Suryanata and Hershock [eds.] 2005; Fox, Yonzon and N. Podger 1996; Gordon, Gurdian and Hale 2003; Offen 2003; Rocheleau 2005; Roth 2009; Hodgson and Schroeder 2002; Wainwright and Bryan 2009; Walker and Peters 2001).

These dilemmas were painfully clear to students as they considered how to represent perceptions and local knowledge documented in the participatory problem assessment: the channel spill zones, points of garbage accumulation, contaminated areas, "critical areas," and areas where children play and areas dangerous for children. The "spill zones" are the points where the channel *begins* to overflow during heavy rains. Although information was not available to represent the *extent* of the overflow from these points, they nevertheless have a greater spatial (and social) impact than can be adequately represented by a small point. The students therefore decided to use a red point surrounded by a dark blue circle to suggest larger spatial extent and impact. They represented points of garbage accumulation with icons that looked like broken down cardboard boxes, and contaminated areas by the well known skull and crossbones symbol, but with a circle to suggest a larger spatial extension. Similarly, residents conceive of "Critical Areas" as relatively extensive, prompting students to represent these with circles in blue and red with different directionality of lines for men's and women's observations, respectively (Figure 5 [one in a series of three maps]). Children's play areas and areas hazardous to children were represented as triangles of green and black, respectively, to simplify map reading but also to make it clear that these areas often overlap (Figure 6 [one in a series of three maps]).

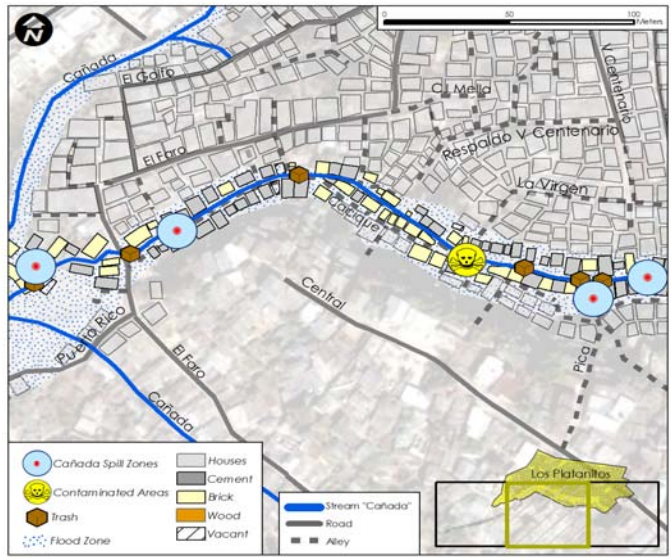

Figure 5. Second in a series of three maps at large scale derived from the participatory problem assessment workshops, showing spill zones, contaminated areas, and areas of garbage accumulation along the channel. Map developed by: Shawn Strange, Martin Thomen and Solange Muñoz. (Sources: CONAU, GoogleEarth and the Community of Los Platanitos).

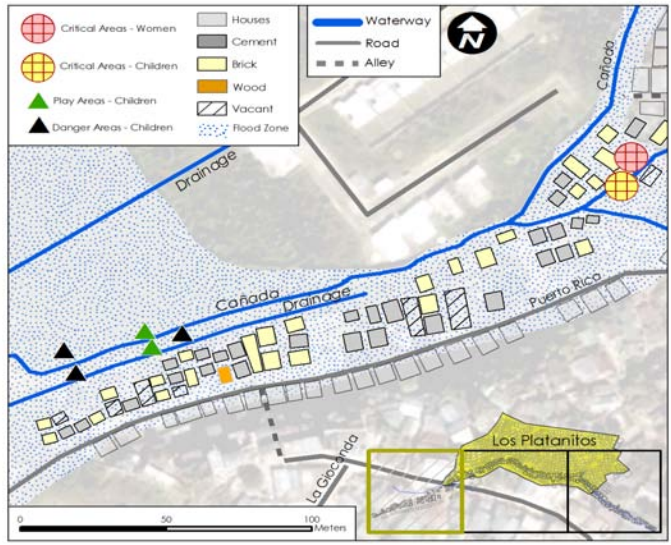

Figure 6. First in a series of three maps at large scale derived from the participatory problem assessment workshops, showing critical areas, places where children play and places considered dangerous to children along the channel. Map developed by: Shawn Strange, Martin Thomen and Solange Muñoz.
(Sources: CONAU, GoogleEarth and the Community of Los Platanitos).

While in the field, students had observed that great volumes of water are channeled into Los Platanitos from the middle-class, densely urbanized neighborhoods located on higher ground just to the north, east and south. These neighborhoods have little or no permeable surfaces and the students mapped an extensive network of street drains that funnel rainwater directly into Los Platanitos. Also, community members report that residents in these surrounding communities routinely throw garbage into Los Platanitos. It was beyond the scope of the students' project to quantify the volume of water that is drained into the community or to assess their claims about the solid waste. However, it was apparent that this additional inflow of surface water was making the flooding—and people's lives—worse. This realization led the students to design these drainage points as relatively large, blue circles with black dots in the center and a black outline, in order to reflect the contradiction between the clean rainfall and the filthy surface runoff water that impacts people's lives in the bottom reaches of Los Platanitos. In other words, the students consciously drew on their technical expertise to present community members' knowledge, as well as their perspective, on the challenges they face on an everyday basis (Figure 7).

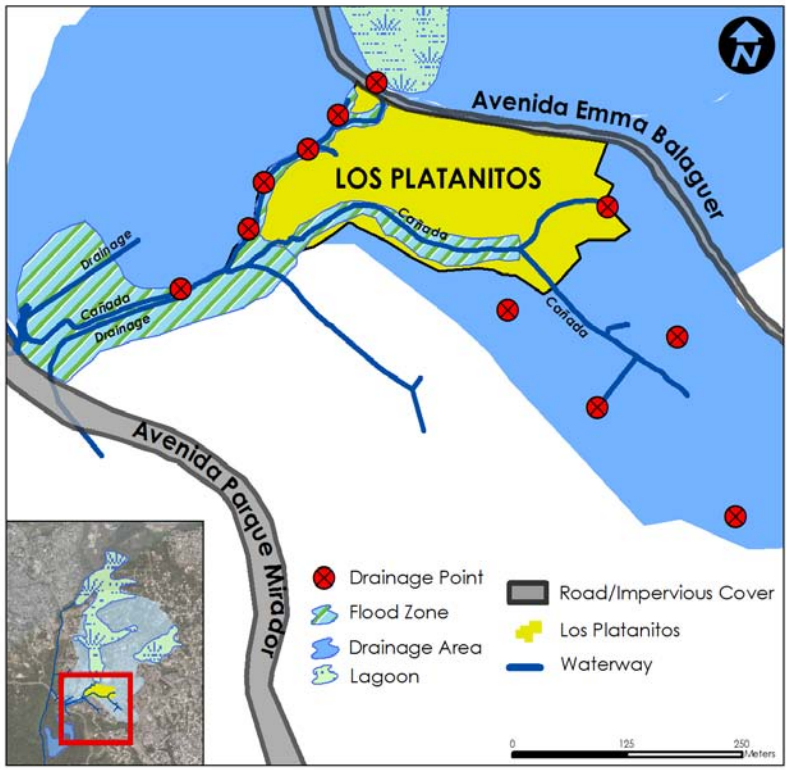

Figure 7. Drainage points and maximum flood level based on local knowledge and students' field observations. Map developed by: Shawn Strange, Martin Thomen and Solange Muñoz. (Sources: CONAU, GoogleEarth and the Community of Los Platanitos).

Conclusions

Ultimately, the maps developed through these short field trips to Santo Domingo can best be thought of as hybrid representations of space, place and landscape, forged through uneasy encounters between "local" and "scientific" knowledges and epistemologies, informed by complex engagements between and among community members, activists, policy makers, the students and the faculty members. Even when students tried to be "objective" in their symbolization, their decision-making was informed by the social contingencies of their knowledge production in the field: the daily, increasingly personal and emotional conversations with community members, the sometimes contentious interactions on the "uncommon ground" of the participatory mapping and problem assessment workshops, and the numerous negotiations and discussions taking place in research teams as they traced alleyways, building footprints, and flood zones.

We hold that such co-production of knowledge is typical of PGIS projects in marginalized communities, in part because knowledge is not simply local or scientific, but socially contextual and informed by powerful assumptions about "better" and more accurate ways of knowing. This is why PGIS, especially when conducted in highly marginalized, impoverished communities, must be accompanied by critical reflection among practitioners and their commitment to open, ongoing, and reflexive dialogue with community members. Here we find inspiration from the field of pedagogy, which asserts that learning, teaching, and "doing" are and should be indistinguishable from each other, just as the development of spatial knowledge should be thought of as a co-production between multiple actors. This leads to our observation that the limitations, opportunities, and aspirations of PGIS projects must be openly acknowledged and discussed with community members; similarly, practitioners and community members alike should be cognizant of the social contingencies of knowledge production and pitfalls and potentials of GIS production and map representation.

Notes

[1] The project was made possible by a Mebane grant awarded by the School of Architecture and by funding from the Lozano Long Institute for Latin American Studies, the LBJ School of Public Affairs, and the Department of Geography, all at the University of Texas. Additional support was provided by the Ayuntamiento Santo Domingo Norte (ASDN), the Consejo Nacional Urbano (now Dirección General de Ordenamiento y Desarrollo Nacional) and the Universidad Autónoma de Santo Domingo. The authors want to thank Dr. Kent Butler, Dr. Frederick Steiner, Dr. Bob Wilson, Dr. Leo Zonn, and Dr. Bryan Roberts at UT for their support; Antonio Alfau and Maryam Kashani for their work on translations and the video; and two anonymous reviewers for their insights and critical reflections. They also want to thank Gabriel Báez of ASDN; Omar Rancier and Lisselote Binet of CONAU, Fermin Antonio Paz of COPADEBA, Marianela Pinales and Sandra Amparo of Ciudad Alternativa, Andrés Navarro García of PARME, and Juan Torres of the Instituto de Urbanismo at UASD, for their support and technical expertise. This work would not have been possible without the friendship, generosity and contributions of the people of Los Platanitos.

[2] The class report can be accessed at http://soa.utexas.edu/crp/info/Rincon_de_los_Olvidados.pdf

[3] We borrow the term "reflective practitioner" from Schön (1987). In planning theory, this refers to the ability of practitioners to reflect on their positionality, identity, relations of power, and the sometimes disruptive roles of technologies and expert knowledge in daily practice. The goal is to work with multiple publics in creative, respectful, and flexible ways that provide residents in marginalized communities with a greater and more meaningful role in developing and evaluating planning strategies.

[4] The 18-minute documentary can be viewed at http://soa.utexas.edu/people/docs/sletto/RincondelosOlvidados.php?l=eng

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