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Research Article

Disparity, Instability, and Power in the Crowdmapping Ecosystem

Renée Sieber, McGill University, *renee.sieber@mcgill.ca*

Ana Brandusescu, McGill University, *ana.brandusescu@mail.mcgill.ca*

Biography

Renée E. Sieber is Associate Professor, Department of Geography and School of Environment, McGill University, Montreal, Canada. E-mail: renee.sieber@mcgill.ca

Ana Brandusescu is PhD Candidate, Department of Geography, McGill University, Montreal, Canada. E-mail: ana.brandusescu@mail.mcgill.ca

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Abstract

Crowdmapping is part of an evolution in participatory mapping, which shifted to the Participatory Geographic Information Systems of stand-alone offline software packages, and now embraces numerous online technologies. In community informatics, we focus on the need to sustain these systems, which supposedly has been dramatically eased with the introduction of online mapping tools and has democratized the technology. The literature is largely absent of the ways in which crowdmapping exists in an ecosystem of private sector and nonprofit actors, operating in an arena of non-human artifacts, such as hardware, software, and data.

We reflect on five community-based crowdmapping applications (apps). All apps were in Canada (Montreal and Vancouver) with goals of fighting densification, highlighting lack of affordable housing and family-oriented greenspaces, promoting community assets, increasing findability of healthy food sources, and collecting perceptions of university spaces. We utilized a design ethnography to identify components of our ecosystem and actor-network theory to map the ecosystem. Our findings reveal the crowdmapping ecosystem (1) faced several interoperability challenges for technical implementation, which brought into sharp relief the disparate skill levels and resource capacities of developer and communities as well as the ability to respond to almost daily modifications in hardware, software, and data; (2) relied on an ever-shifting network of individuals and organizations in large part because of unsustainable business models serving a top-down governance; and (3) exposed power differentials among a mix of funders, tech-for-good nonprofits, private sector hardware and software providers, and the underlying non-human actors. Lessons learned from this ecosystem inform crowdmapping as it evolves and engages newer actors and technologies, which further inform community-based organizations as well as researchers and philanthropic funders who may promote overly complex solutions to suit particular agendas.

Keywords: mapping, community development, ICT and development.

Introduction

Maps offer powerful visual representations of the spatial distribution of activities and perceptions in a community. One effective way for communities to map their spaces is via crowdsourcing, since it can enable many residents to contribute their location-specific lived experiences, injustices, and significant events. Crowdsourced mapping, or crowdmapping, can be defined as the peer production of geographic information that is contributed and then mapped online. Advances in ICTs such as digital platforms, extensible software libraries, application programming interfaces (APIs), and real time reporting via mobile phones can allow even poorly resourced community-based organizations (CBOs) to rapidly synthesize content and generate maps (Sieber et al., 2016). This rapid mapmaking is achieved because volunteers can both contribute mapping data and develop applications (apps), which often are based on free and open-source software (FOSS) (Goodchild, 2007). These volunteers tend to be non-experts, whose contributions reflect their knowledge of the area rather than their expertise of a subject.

Historically, much of the literature referring to crowdmapping has focused on its application to crises, whether natural or human-induced (Brandusescu et al., 2016). The best-known application of crowdmapping was the use of Ushahidi software to aid individuals affected by the Haiti Earthquake (Forrest, 2010). Zook et al. (2010, p. 18) detailed the abundance of software, data and people devoted to mapping humanitarian aid: "Spanning multiple [open source] tools, such as Akvo and Sahana, the concentrated efforts by CrisisCamp volunteers to contribute were perhaps most visible with respect to the development of OpenStreetMap (OSM) information in Haiti's urban areas." We were struck by an anonymous post cited in Zook et al. (2010, p. 18) on all the tools needed for the assistance: "Using every sort of collaborative and social media tool (open source projects, shared workspaces, Wikis, blogs, Skype, chat, Twitter [X], Facebook, etc.) this group has pioneered a new kind of aid organization, working hard to provide tools and information vital [to] the mission of helping Haiti recover." For them, mapping was no longer one software or solely a group of experts but existed as a crowdsourced and "mashed up" ecosystem of aid.

A crowdmapped ecosystem (hereafter, ecosystem) represented a technical shift in the way locational technologies addressed crises, acute and chronic. It also enabled a socio-political shift, embedding multiple new actors and their ideologies. The actors could include new groups of citizens but also new public and private sector participants. Accompanying some new actors were "non-state (market and corporate) regimes of spatial data governance, which was consonant with new, post- dot.com logics of free labour, private ownership, and supra-accountability that may be framed in terms of the imperatives of technoscientific capitalism" (Leszczynski, 2012). Not only were there additional media to contribute locational content but also to build one's own bespoke mapping application from software and hardware components. Our focus is on how locational technologies have been disaggregated into pieces and how so much of the new regimes of locational or geospatial web (geoweb) technologies[1] relied on the pieces being "highly interconnected" or optimized to function (Palfrey & Gasser, 2012). As organizations have increasingly relied on—indeed some exist as a result of—this arrangement, it is worthwhile to examine the capacity for an ecosystem to remain interoperable, when it involves poorly resourced CBOs advocating for social justice.

A belief that decentralization and open-source leads to greater democracy, transparency, and community control can obscure critical reflection on the sustainability of crowdsourced systems like mapping (de Souza et al., 2021). For us, sustainability refers to the social, economic, and technical requirements to maintain the apps. Sustainability is central to our study because

[1] Technically, the geoweb refers to the technologies supporting the organization and delivery of geospatial content on the web. Crowdmapping adds the non-expert contributions, although some do not differentiate between the two concepts.

our focus on crowdmapping involves empowering community members to leverage emerging platforms and hardware to create their own data collection and analysis tools. We examine crowdmapping instances through platforms like Ushahidi, emphasizing actors and technological systems beyond the direct control of community members. A decentralized approach, which includes a shifting array of external actors and dynamics, highlights crowdmapping efforts. We reflect on five crowdmapping apps that we deployed, four of which were for CBOs. Numerous challenges emerged that are common in community informatics (e.g., Gurstein, 2007). We argue that community informatics have not adequately captured the movement from desktop-single source software to apps dependent on a cloud-/web-based ecosystem and we worry, remain ill-prepared to cover new challenges as technologies are either increasingly decentralized or re-centralized (e.g., under Big Tech).

Our paper begins with the evolution of community mapping into crowdmapping and the blurring of public and private, as well as the infusion of crowdmapping with private sector orientation and libertarian ideologies found in technology- and market-driven philanthropy. This begins to suggest the complexity of the ecosystem. We then describe three main findings of the crowdmapping ecosystem, technology, people/organizations, and ideology. First, the ecosystem faces several interoperability challenges for technical implementation, which are brought into sharp relief when the developer and community lack skills and other capacities. Second, the ecosystem relies on an ever-changing network of individuals and groups in large part because of unsustainable business models. Third, the ecosystem is embedded within and subject to particular ideologies.

We conclude with lessons learned to contextualize emergent technologies to assess the stability of the ecosystem. Some findings harken back to durable critiques of technology-led community development (Gurstein, 2007). They also demonstrate that these new modes and exhortations, about FOSS, about democratization through decentralization, only partially ameliorate the critiques.

Crowdmapping and its mashed-up ecosystem of humans and non-humans

Geographers have discussed the role of computer-assisted community mapping for over 20 years, with Public Participation Geographic Information Systems (PPGIS), and by extension, GIS. One vision for PPGIS was to enable community-led initiatives to leverage the capabilities of geospatial technologies, traditionally controlled by corporate and state entities, to map local knowledge and influence policymaking (Sieber, 2006). In these initiatives, GIS software remained the dominant development platform. However, GIS was and continues to be expensive and unwieldy with a steep learning curve and strict rules about data management. Computerized mapping has “devolved” into a multiplicity of apps, digital platforms, and the actors who develop and fund them (Crooks et al., 2014). Instead of a single package managing spatial data, mapping now comprises numerous “mashed up” components: user interfaces (UIs), software libraries (e.g., R), databases, geospatial geometry and, more often, distributed through the cloud (Zook & Breen, 2017). Many components, like APIs for geocoding, are modular and designed for easy integration. Components allow for user-specific customizations, for example of the UI.

Crowdmaps are global, with contributors and cloud storage spread worldwide. This modular approach presumably accelerates development, with simple lines of code from platforms like YouTube or Google Maps delivering full functionality, including video libraries or interactive maps.

Because the locus of power for GIS applications has resided in the public sector (e.g., land use management), the data traditionally originates within government. The geoweb, the suite of technical components and data, marks a shift from reliance on that authoritative data to user-generated content, where non-experts act as legitimate sensors of their environment to contribute Volunteered Geographic Information (VGI) (Yan et al., 2020). This shift suggests that technological barriers no longer represent the main challenge for PPGIS (Aranda et al., 2023). The geoweb supposedly enhances community empowerment as members add their local knowledge to authoritative content in real time; it promotes collaboration and further democratizes access to mapping tools (Kar et al., 2016; Sieber et al., 2016). The systems can integrate unstructured text and democratize the ability to work outside the strictures of a stand-alone proprietary packages and data structures (ibid.). Greater promised inclusivity does not guarantee increased participation. In an era of ubiquitous mobile phones, we can forget that contributions do not seamlessly appear on a map; technical components are required for the transfer from contribution to the geoweb (e.g., software to handle short message service {SMS}, hardware like modems and SIM cards). The geoweb assumes users have coding skills to ensure component interoperability, which can promote choice and innovation but also demands software literacy (Palfrey & Gasser, 2012).

Technological advances are frequently enabled by Free and Open-Source Software (FOSS). More than a software development model, FOSS exemplifies a movement that should democratize GIS (Moreno-Sanchez & Brovelli, 2023), allowing the source code to be freely accessed and collaboratively developed. This technological egalitarianism shares traits with crowdsourcing, which Brabham (2009, p. 242) described as an “online, distributed problem-solving and production model,” though crowdsourcing may involve paid labor. Both FOSS and crowdsourcing are driven by norms, offering quicker, more efficient, and adaptable solutions. Crisis mapping activists like Okolloh (2009) praised the speed and scalability of open-source tools for crisis management. Norheim-Hagtun and Meier (2010) highlighted FOSS’s ability to mobilize volunteers, ensure free distribution, and enable customization. FOSS represents a form of altruism, addressing unmet needs (Green, 1999 in Bonaccorsi & Rossi, 2003) and creating collective benefits, aligning with Stallman’s ideologies of openness, egalitarianism, and freedom in the GNU Manifesto (Stallman, 1985).

The FOSS movement highlights the potential instability of a crowdmapping ecosystem. By design, FOSS depends on voluntary contributions driven by non-monetary incentives like social status and intellectual fulfillment. Coordination is decentralized and non-coercive, with software often shared on platforms like GitHub (Bonaccorsi & Rossi, 2003). However, if no one volunteers for critical tasks then projects risk stagnation. Ecosystem instability also can be a consequence of corporate control, which is paradoxical to FOSS because the movement supports decentralized control and individual empowerment. Reliance on corporate-controlled platforms can make developers vulnerable, as shown by the deactivation of the Google Earth API (Brennan, 2016).

FOSS's perpetually evolving nature leaves it in a beta state, requiring end users to adapt continuously (danpetry, 2007). Moreover, the assumption that all users are skilled coders creates barriers for non-technical users, contradicting FOSS's egalitarian claims (Perez, 2007). CBOs often lack the expertise and resources to keep up with these evolving technologies (Brandusescu et al., 2016; Sieber et al., 2016). Leszczynski (2012) warned that these systems exist within a mix of contrary impulses: the need for free labour, private ownership, and lack of accountability. To these contradictory impulses, Bittner et al. (2016), Elwood and Leszczynski (2011), and Palmer (2014) added concerns about the power of the Ushahidi UI, particularly when combined with Google Maps, to produce hegemonic or overly totalizing visualizations. Palmer (2014, p. 342) argued that advocacy organizations such as Ushahidi Inc. could still be critiqued for their partnerships with firms like Google. Although Ushahidi Inc. has presented itself as a group of activists focused on mapping testimonies, its dependence on Google's corporate-driven humanitarian mappings raises concerns about the effectiveness of a project that ultimately is top-down.

Crowdmapping is also influenced by corporate ideologies, evinced by the priorities of funders. We see this in the concept of "philanthrocapitalism," coined by Bishop and Green (2009), which merges charitable activities with market-driven goals. Philanthrocapitalism's funding priorities include greater economic accountability and solutions as well as reduction of inefficiencies and overall costs (Burns, 2019; Haydon et al., 2021). This framework can embed profit-oriented principles into crowdmapping efforts, potentially shifting focus from local community needs to broader market interests.

Philanthrocapitalism often demands CBOs become social entrepreneurs. Social entrepreneurship, which gained prominence in the 1990s, involves individuals, groups, or start-ups who develop, fund, and implement solutions to societal or environmental issues (Leadbeater, 1997). Like philanthrocapitalism, it emphasizes market-driven approaches to address societal problems through innovation and business strategies. Both philanthrocapitalism and social entrepreneurship are popular in the tech sector where numerous tech firms and their founders created foundations to fund nonprofits in emergent fields like digital humanitarianism (e.g., Omidyar Network, Google.org). These organizations frequently fund tech nonprofits because tech is seen as an appropriate solution for the world's problems. Philanthrocapitalism and social entrepreneurship align with the larger concept of neoliberalism, which superimposes onto non-private actors private sector principles (Harvey, 2005). Neoliberalism not only encompasses the downloading of traditional state functions onto civil society but also the market's ideas around commodifying social ties (Marwick & boyd, 2011). By commodying social ties community connections are transformed into marketable assets.

Social entrepreneurship operates through business models like impact investment, targeting risk-averse investors from Silicon Valley who seek safe returns (Ogachi & Zoltan, 2023; Rosen & Alvarez León, 2022). To reduce financial risks, these initiatives often exploit volunteers for data collection and software development. Crowdmapping thus responds to austerity in the public and nonprofit sectors through the contingency on free labour. Without crowdsourcing, public sector agencies may simply lack the resources to process data (Burns, 2019). Similar to FOSS, the public acts as a reserve labour force for relief efforts. Crowdmapping aids the corporatization of humanitarian assistance, where volunteer work supports capital accumulation (Burns, 2014). Despite terms like 'shared value' and 'partnership', philanthrocapitalist and social entrepreneur models can result in unintended harms, including predatory partnerships (McGoey, 2021).

Overall, crowdmapping offers an appealing ecosystem because it can be combined in an ad hoc fashion, is supposedly easy to manage, and is mostly free and open. Crowdmapping promises to extend the decentralization of power through the ecosystem. Teli et al. (2021) argued that one could create platforms that support a compassionate economy via "platforms for good." Platforms could be designed so that collaboration becomes a means of fostering liberation and empowerment. However, maintaining a particular app or platform ecosystem can require access to high levels of technical expertise. The ecosystem depends on a pool of willing FOSS participants as well as interventions from the private sector and funders. Through five apps, we tracked the sustainability of the crowdmapping ecosystem to determine just how interoperable it truly was with hints for the future.

Methodology

We utilized a design ethnography approach, which combines methods to understand community practices and requirements to improve services or systems (Baskerville & Myers, 2015; Salvador et al., 1999). As part of our design ethnography, we co-designed and developed apps, conducted participant observation and informal consultations, performed a content analysis, and mapped the ecosystem using actor-network theory (ANT).

We initially unpacked the ecosystem of the apps by co-designing and collaboratively developing five crowdmapping apps. Four apps were built in collaboration with CBOs, which were focused on community development for low-and middle-income communities. University Spaces was our test app where we prototyped our co-design methods. We conducted extensive and iterative consultations with community organizers, including workshops with community members and preparation of education materials, for example, storyboards to introduce the apps and manuals for CBOs to sustain the apps. More details about research with community members can be found in Brandusescu (2014). All apps were in Canada, three in Montreal and two in Vancouver. Their goals were to fight densification, highlight lack of affordable housing and family-oriented greenspaces, promote community assets, increase findability of healthy food sources, and collect perceptions of university spaces. Table 1 showcases our different apps, location, goal, and technology stack. As we developed a uniform tech stack, we provide instances of all the components we needed to use.

All apps used Crowdmap, a less technical and more user-friendly version of Ushahidi (we call crowdmapping the practice and Crowdmap the tool). Ushahidi is software developed and maintained by the nonprofit Ushahidi Inc. (Marsden & Oduor Lungati, 2023). Community co-development and interaction with the apps is detailed elsewhere (Brandusescu et al., 2016). Here we describe how much the apps existed within a geographically widespread and fragile network of apps, APIs, hardware and software platforms, and the firms and funders that support them, which we discovered during app development and deployment.

Because our main focus is those actors external to the community, we conducted an analysis subsequent to Brandusescu et al. (2016). We consulted with representatives of Ushahidi Inc., FrontlineSMS, and philanthropic organizations. We participated in forums like Ushahidi and the Humanitarian OSM Team (HOT) and on Ushahidi's designated GitHub page (e.g., to submit technical issues). This kind of participant observation (Musante & DeWalt, 2010) improved our understanding of the human actors and their relationships in the crowdmapping ecosystem.

Table 1. Overview of the Five Applications

<table>
<tr><th>Application Name</th><th>Location of Communities</th><th>Goal</th><th>Tech Stack</th></tr>
<tr><td>Espaces Lachine</td><td>Lachine, Quebec
French, English</td><td>Mapping community assets, community improvements, youth engagement; facilitating youth education
Primarily low-income; increasingly gentrified by professional class</td><td rowspan="5">GSM modem and SIM cards
Phone SMS and data plans
Stable internet connection, browsers (types and versions)
Coding (PHP)
GitHub
FrontlineSMS software (as an intermediary between SMSs and the Crowdmap platform)
Ushahidi online/offline smartphone mobile apps
Mail server (e.g., email accounts and server to send/receive emails)
Twitter (now X) platform and hashtags
Crowdmap platform (e.g., back-end and front-end)
Hosting servers
Crowdmap platform with various communication features turned on (e.g., email, Web form, Twitter, Ushahidi smartphone application)
Unique URL registration for app
Base map (e.g., Google Maps or OSM) and customized UI
Database of community contributions</td></tr>
<tr><td>Saine Alimentation</td><td>Lachine, Quebec
French, English</td><td>Mapping improved nutrition
Primarily low-income; increasingly gentrified by professional class</td></tr>
<tr><td>Acadia Park Spaces</td><td>Vancouver, British Columbia
English, Mandarin, Spanish, Farsi</td><td>Created to map out the threat of land-use change from housing to commercial units; Mapping community assets, community improvements, anti-rezoning, anti-densification
Primarily low income graduate students and their families; professional class; all-volunteer</td></tr>
<tr><td>Let the People Speak</td><td>Vancouver, British Columbia
English, Mandarin</td><td>Mapping anti-densification, anti-rezoning, social housing, community plan
Primarily middle income; all-volunteer</td></tr>
<tr><td>University Spaces</td><td>Montreal, Quebec
English, French</td><td>Test out platform; have students contribute their perceptions of physical spaces at McGill University downtown campus
Primarily middle income staff; undergraduate students; all-volunteer</td></tr>
</table>

We employed an inductive content analysis, which includes a three-step process of open coding, category creation, and abstraction (Elo & Kyngäs, 2008) of grey and academic literature to extract themes. Review of our field notes and email exchanges not only revealed community collaborations around app development, but also technical interoperability challenges. We augmented our analysis of app development and implementation with an analysis of the dynamics of non-human actors that comprised the components upon which our apps depended. Themes emerged from our content analysis, which further augmented the overarching themes in our results.

We utilized ANT to map the interoperability and stability of the crowdmapping ecosystem. ANT frames technical innovations in terms of entities (actors) and associations among them. The use of ANT in the diffusion of information and communications technologies (ICTs) is not new (Sangiambut & Sieber, 2017). The value of ANT to ICT research is that artifacts, in our case the hardware, software, data, or communications media as well as institutions, have a momentum and agency of their own distinct from the human agents who contribute to them (Callon & Latour, 1981, p. 284). Both humans and artifacts become actors in the network: any entity that "acts or to which activity is granted by others" (Latour, 1996, p. 373). Actions include a shift in one actor's makeup because of the actions of another or a merging of two actors into a different actor. Actions of one actor could even result in the disappearance of an actor.

To explicate the network, Dankert (2011) suggested that one chooses an actor as a starting point. From there, the researcher can unpack one actor to reveal the larger network. Latour (1996) described "unpacking the black box" as a method to reveal the hidden complexities behind established and unquestioned procedures. By unpacking the black box, we expose the actors, practices, ideologies and agendas that give the ecosystem form. For us, the starting point is Ushahidi, which we then explicated to a wider range of human and non-human actors involved with the software.

Results

Our research found that crowdmapping is neither a stand-alone software package from a one developer nor a single cloud-based software platform. Instead, crowdmapping is an ecosystem of many interoperable actors with unstable components, and power differentials.

Figure 1 shows the ecosystem that we uncovered in our research. Unpacking Ushahidi revealed distinct telecommunications hardware, software, mapping and remote software, and servers. We grouped them in three boxes. Box 1 contains the technical artifacts that have achieved a durability beyond the individual users, including the ability to influence human actors. Box 2 concerns the developers of platforms, their funders, developers of apps (e.g., us as researchers), and remote mappers, as well as other actors who influence the resultant app. Ideologies informed the shaping of these actors so profoundly that they deserved a materiality of their own and displayed in Box 3. The boxes in Figure 1 categorize the three issues that emerged regarding the crowdmapping ecosystem: the challenges of making the hardware and software interoperable; the human actors and the associated stability of their business models; and lastly, the way the ecosystem exposes ideology and power, which permeate through the ecosystem.

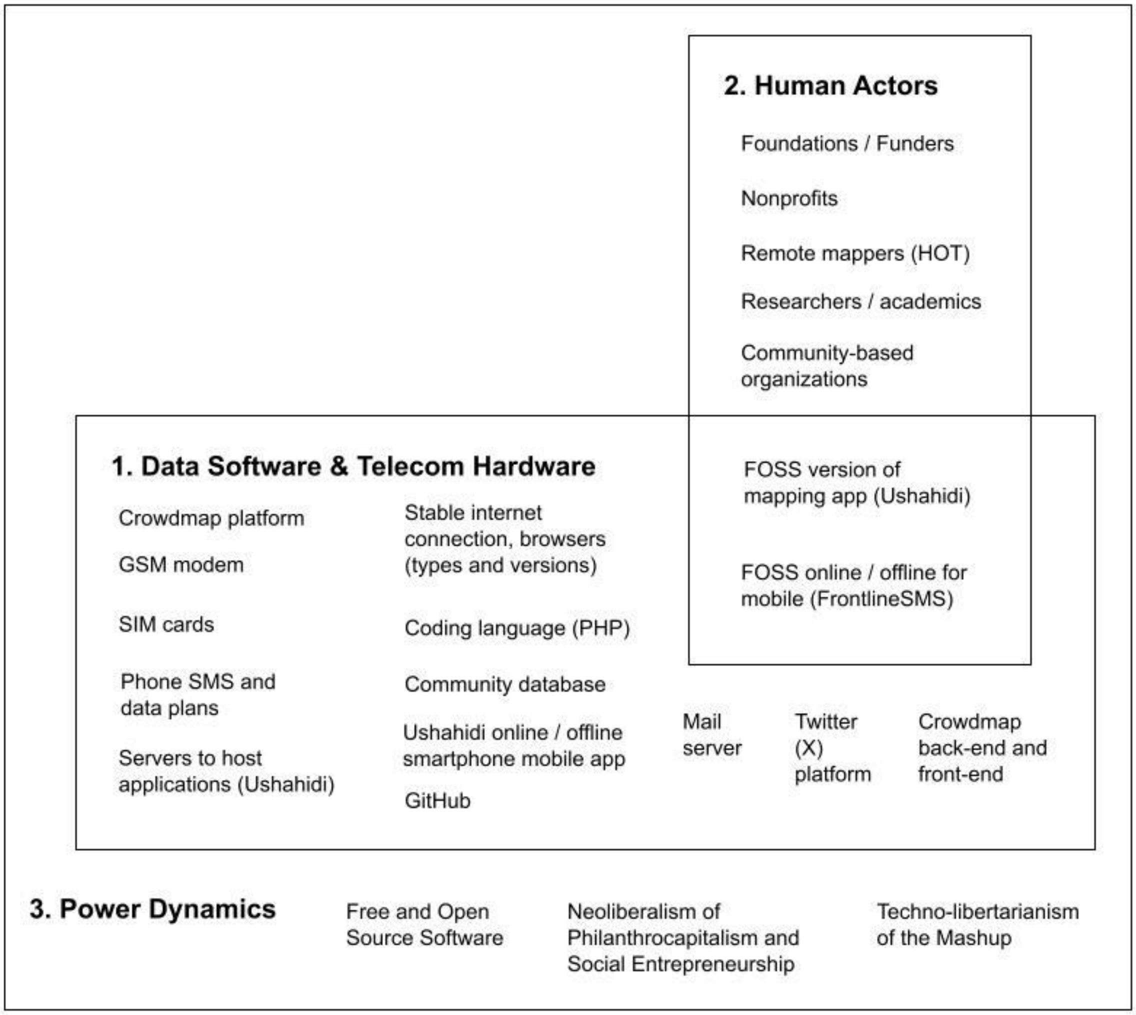

Figure 1. The Crowdmapping Ecosystem

Platforms, software and telecom hardware reveal inoperable junctures

Our first finding emerged as we co-designed and developed the five apps. Per Dankert (2011), we started with a specific crowdmapping platform from Ushahidi Inc. Selection of a particular platform imposed part of the ecosystem on us. Not only has Ushahidi been the best-known software platform[2] for crowdmapping, Ushahidi is FOSS and is promoted as highly repurposable.

[2] A software platform is distinguishable from a software product in that the former almost exclusively runs in the cloud, which means it operates as an ecosystem and offers building blocks upon which a developer can construct their application.

Originally designed for crisis mapping in Global South countries, a developer could shift the software platform's intent to community development in Global North cities.

Figure 1, Box 1 shows the software and hardware comprising the ecosystem for our five apps. We first installed the Ushahidi software on a local machine, available from the collaborative software development platform, GitHub. As we installed the software, we documented the required steps in the process (e.g., to set up Ushahidi on a CBO's server). We soon realized that maintaining Ushahidi was likely too complicated for CBOs. Had CBOs used Ushahidi, they would need additional actors—one's own server, a programming language (i.e., Javascript), and a system administrator—to develop as well as sustain the system. For these reasons, Bittner et al. (2013) likened software from Ushahidi Inc. to a 'black box.' "Those scripts bear the code which enables (and restricts) the interactive behavior of the website and the map interface" (Bittner et al., 2013, p. 937). Absent technical interaction in modifying the code and associated mapping data, the software furthered a 'one view of the world' discourse that excluded other representations.

We subsequently deployed the "simpler" version of Ushahidi, Crowdmap, which was promoted as having a flatter learning curve than Ushahidi (Brandusescu et al., 2016). Hosted on external servers, Crowdmap was established as a software as a service (SaaS). With SaaS, software usage is cloud-based. Developers build apps on top of Crowdmap; the base software platform is maintained by Ushahidi Inc. The servers hosting the software physically exist in a location that may be distant from other actors in the ecosystem, who may be unaware of that location. Servers in a SaaS are meant not to serve as actors at all. They are meant to exert no influence. However, physical server location can determine the laws to which they (and their data and software) are subject (Sangiambut & Sieber, 2017) and servers may be vulnerable to location-based disruptions such as wars and civil unrest. Consequently, hosting servers emerge as an unavoidable part of the ecosystem.

Crowdmap offered several underlying data sources (the base map) for the area. In two of our Montreal apps, the CBO chose OSM because members appreciated the community nature of the layer. The other three apps relied on Google Maps tiles. OSM is considered a "map of the world" created collaboratively by local and remote mappers (OpenStreetMap, 2024). The OSM volunteer community contributes the mapping data and builds the data storage and visualization software. The choice increased the dependency of Crowdmap apps on the OSM community to maintain the points, roads, and other features in the spatial database. By contrast, Google Maps maintains its own data storage and rendering software and uses proprietary digital imagery (the mapping tiles) owned by third party firms. To give a sense of all the organizations involved in providing imagery for the City of Vancouver (one of our sites), map data and images were supplied by Google, Province of British Columbia, IMTCAN, DataSIO, NOAA, US Navy, NGA, and GEBCO.

We move from the mapping portion of app development to methods of capturing contributions. Identifying and procuring necessary components, for example mobile phone hardware components, that would be interoperable proved to be quite challenging (Brandusescu et al., 2016). Decisions made on which mobile network is adopted by a country largely depend on the federal government and the telecom ecosystem (e.g., ITU, mobile providers). At the time, if users wanted to add precise location-based content from their phones then they needed an SMS service. FrontlineSMS was the only texting provider that was interoperable with Crowdmap. FrontlineSMS required hardware that complied with the Global System for Mobile (GSM) communication network, available primarily in Europe and other parts of the world and, to a lesser extent, North America. In the first round of our research (2011-2013), two thirds of Canada's mobile network providers were under the Code Division Multiple Access (CDMA) telecommunications network. (The majority of telecommunications providers, including both Bell and TELUS are now under the GSM network.) Additionally, the ecosystem of phone calls and SMSs constantly changed during and post deployment of our apps. A subsequent version of FrontlineSMS (2.0) no longer required a modem. Hardware was replaced with a separate cloud-based SMS "aggregator" service, which harvested and then transformed an SMS into content that could be read by a browser. As recently as 2020, aggregator services remained cost-prohibitive and not available in the country in which the app was used (FrontlineCloud, 2020).

Ushahidi continues to support SMS contributions, but over time its primary method for adding content shifted to a mobile-based app. The Ushahidi platform now allows for additional data sources (e.g., custom surveys), data management that can filter searches and enable team collaboration, data visualization that includes mapping as well as configurable charts and automatic alerts like email notification and SMS alerts (Ushahidi, 2024). The adoption of innovations in data collection, management and governance has eliminated the need for FrontlineSMS. Our review of the platform revealed that Ushahidi now supplies its own SMS software (SMSsync), although SMSsync requires installation[3] and users need to pay for sending a text (only available on Android).

Development time was exacerbated by uncertainty about the Crowdmap platform during app development and its future versions, which were often short-lived (Ushahidi, 2013; 2015). The later versions of Ushahidi resembled the ease of Crowdmap's SaaS. To this end, a FOSS version of Ushahidi is still downloadable that can be installed and maintained on one's own servers. (A paid version is available from Ushahidi that uses their servers.)

Overall, shifting software and hardware requirements created considerable unreliability and risk in the ecosystem as well as confusion to developers. Not only must they keep up with software innovations, but developers also likely need to support older technologies and software versions that may be prevalent in a specific community. We found that developers needing to support classic hardware (e.g., non-smartphones) would build an app that was interoperable with a specific telecom; however, another portion of the ecosystem would break it. Changes in configurations or innovations in software can be devastating to developers of community-based apps because the work is often volunteer-based and temporary, with developers only possessing superficial knowledge about the range of skills necessary for implementation (Gurstein, 2007). In some instances, community members may have switched to smartphones and no longer need

[3] https://docs.ushahidi.com/platform-user-manual/3.-configuring-your-deployment/3.4-data-sources/3.4.5-smssync

modems; however, accessibility (e.g., for the elderly, the poor) requires a large range of communication mediums, browser versions, and data plans.

App development relies on multitude of actors with shaky business models

Our second finding concerned instability emergent from the human actors in the ecosystem, as shown in Box 2, Figure 1. The Ushahidi platform was developed by three bloggers and one software developer in 2008, as a "labour of love" to create a platform for Kenyans to report and then map post-election violence (Adewumi, 2008). Shortly thereafter, Ushahidi was incorporated in the US as an ICT for Development (ICT4D) business and nonprofit incubator, with operations in Nairobi, Kenya.

Irrespective of the technical details of Ushahidi the platform, Ushahidi Inc. began to struggle with brand recognition as Crowdmap gained popularity (Ushahidi, 2015). After the development of our apps, Ushahidi Inc. discontinued Crowdmap. Ushahidi Inc. representatives stressed the importance of the name Ushahidi: "as we have grown and tried all these new things, we have come to recognize that our community sees […] the crowdsourcing platform, as synonymous with our brand name, Ushahidi" (Ushahidi, 2015). According to a Harvard Report (Kylander & Stone, 2012), a brand was once seen as a communications tool for funders and the general public. Increasingly brands are considered important "psychological constructs," held by those familiar with the product, nonprofit, or movement" (Kylander & Stone, 2012, p. 38). Likewise, the composition of the ecosystem shifted due to financial constraints, not technical innovation. As cloud hosting became a major cost to the organization, Ushahidi Inc. decided to phase out free hosting for Crowdmap Classic since the Ushahidi version was designed to be hosted on individual developers' machines (Hinga, 2020).

FrontlineSMS, the organization, also was important to the ecosystem. The firm began in 2005 as "one of the first platforms to help harness the power of mobile technology for social change", which recognized the widespread usage of SMS in Africa (FrontlineSMS, 2018a). FrontlineSMS initially relied on a FOSS model of volunteer contributors to build and maintain the software. Organization members eventually recognized the limits of FOSS, so four years later they hired an in-house developer (FrontlineSMS, 2018b; 2018c). In 2015, FrontlineSMS entered into a partnership with Occam Technologies Inc.; Occam subsequently partnered with Google Cloud to deliver Internet of Things solutions for the business service sector (Troconis, 2018). A possible solution for FOSS-based civic technology may be to 'spin off' a private sector company to subsidize development; that private sector firm may establish relations with other firms. Ecosystem sustainability may demand these new actors. However, these activities invariably blur the distinction between nonprofit and private actors and can result in for-profit activities receiving a higher priority than the nonprofits.

In community informatics, we discuss the needs for CBOs to secure funding. However, the Ushahidi and FrontlineSMS organizations relied on a broad network of funders, including foundations (e.g., Omidyar Network), trade associations (e.g., Groupe Speciale Mobile Association--GSMA), telecom providers (e.g., Vodafone), and private firms (e.g., Google).

Relationships with funders are often fraught. Uncertain funding can induce significant volatility for a nonprofit's operational capacity, in terms of sustainable programs, long-term strategy, and staff retention. It also can derail a nonprofit's mission as organizations scramble to qualify for narrowly prescribed program funding. Moreover, uncertain funding can self-censor a nonprofit's collective voice if that organization is perceived to be too advocacy-oriented. And lastly, it can download responsibilities from the government to the nonprofit, particularly if the government is a funder, and increase administrative time, for instance, for larger reporting requirements (Gupta et al., 2020; Scott, 2003). The ultimate impact of nonprofits can result in a "House of cards, [where] the end of one partnership agreement can bring down the whole interlocking structure" (Scott, 2003, p. xiv).

Ushahidi Inc. recognized the need to reduce reliance on large private foundations by diversifying funding toward earned income (Afrinnovator, 2011). Encouraged by funders like the Omidyar Network, both Ushahidi and FrontlineSMS adopted the social entrepreneur model, focusing on low-risk investments and scaling up strategies (Ogachi & Zoltan, 2023). Latter strategies include broadening the pool of investors and delivering services that can be generalized to multiple communities and applications. The mantra to always "innovate" or "scale up" was linked to the nonprofits' ability to secure funding. If nonprofits simply customized existing technologies without pushing boundaries, they risked losing financial support. The nonprofit's business model constantly navigates tensions over non/for profit strategies, directives from the state and overall volatility, which all exert a powerful influence on the nonprofit.

One needed unpacking of the HOT ecosystem pertained to contributors of the baseline geographic information (Herfort et al., 2021). Four apps were deployed in low-to-moderate income neighbourhoods within prosperous cities within Canada. As a practice, HOT does not marshal volunteers to contribute content in wealthy areas or the Global North. These neighbourhoods are not considered sufficiently vulnerable to warrant the type and immediacy of content contributed for crises. Stephens (2013) noted how OSM contributions, particularly those deemed political, could run afoul of the moderators who did not believe those additions align with the mission of OSM. We applied Crowdmap to chronic crises like urban food deserts. Unpacking parts of the ecosystem reveals how actors respond to what amounts to "slow violence" (Nixon, 2011) of structural inequality in wealthy Global North cities as opposed to the acute violence of natural disasters in the Global South.

Whether chronic or acute, funders, OSM contributors, software nonprofits, and cloud facilities all were remote. A large team, such as Ushahidi Inc.'s, can only expend so much effort supporting the needs of a local community. Furthermore, a local CBO may need to support old models of phones, user contribution mechanisms, modems and SIMs, and APIs. Given Ushahidi Inc.'s own challenges, it was hardly surprising to find that our apps' community users also struggled with changes during application development.

Power and ideology dominate the ecosystem

Our experience in the ecosystem of crowdmapping was mirrored by other apps revealing "complex […] networks in environments with immature technological systems, the unreasonable demands for sustainability, and the genesis of many projects outside the human environments most affected by them" (Cisler, 2005, p. 146). We observed vulnerability in the ecosystem due to its reliance on technical and non-technical actors but also on a set of interlocking ideologies. When diverse actors with entirely different agendas or priorities operate in a series of networks that make up the ecosystem, it only increases the likelihood of breakage.

Our ecosystem invoked philanthrocapitalism and social entrepreneurship. Researchers discovered that funders could become frustrated by the lack of systemic political and economic change, perceiving nonprofits as ineffective in driving reforms (Parks, 2008). ICTs promises a means to disrupt inflexible agency practices and advance rapid change sought by funders (Burns, 2019). Ushahidi Inc. appeals to philanthrocapitalists because it resembles for profits in terms of scalability and potential to achieve efficiencies of social impact. By 2009, Ushahidi Inc. strengthened its for profit side with apps in over 20 countries, with the goal of fostering an ICT innovation culture in Kenya and eastern Africa more broadly (Ogachi & Zoltan, 2023). Part of the ICT company iHub, the Ushahidi ecosystem now includes entrepreneurs, venture capitalists seeking returns, investment bankers, and micro-to-small-to-medium enterprises, creating a dynamic environment for growth and technological innovation (ibid). Championing innovations means tech nonprofits can more easily demonstrate their fidelity to a for-profit ideology of social entrepreneurship.

Parks (2008, p. 213) warned that nonprofits can become captive to funders' agendas when power asymmetries are great. Asserting power means the ability to define what constitutes the goals of the nonprofit. Omidyar Network, a funder of Ushahidi Inc. since 2009, has quantified metrics for social impact success (and failure) (Bannick & Hallstein, 2012), such as the number of people reached, submissions / reports, lives saved, percentage increase in voter turnout (Hersman, 2009). Indeed, Ushahidi asserts that "[q]uantifying our impact is of utmost importance [when] impact is highly contingent on the activities of our partners" (Ushahidi, 2023).

Our research highlights the dual influence of funder and private sector ideologies on app development and their role in determining technology's impact on society. The Province of Quebec, where two of our apps were based, began a shift in its funding and perception of CBOs in the early 2000s. Researchers reported that "[C]ommunity organizations are seen primarily as mere service providers and not as agents of civil society in a democratic framework" (Caillouette, 2004, p. 1). Unlike the U.S., Canadian CBOs are more captive to government funding, with neoliberal policies like market-based regulations pushing them towards a business model and away from a focus on community members (Evans et al., 2005). This shift also could dampen CBOs' advocacy roles and limit funding for expanding their ICT capacity beyond what the government considered core service delivery. Consequently, many may lack the resources to manage the capriciousness of the ecosystem.

In Vancouver, we also observed less top-down philanthrocapitalism and more bottom-up manifestations of social entrepreneurship, where participants internalized market principles to conduct advocacy (e.g., through number of likes and contributions). We witnessed considerable pushback to this commodification of the self as our participants were frequently skeptical of crowdmapping, in one case because the state had deployed a similar mapping technology (Brandusescu & Sieber, 2018). Another CBO actively resisted Crowdmap because it could not control the ownership of the tool. The tool also encouraged communities to act like consumers, not citizens.

Our ecosystem (Figure 1, Boxes 1 & 2) contained several FOSS actors. Even though FOSS principles involve distributed egalitarian collaboration, to be successful each FOSS should include “a widely accepted leadership setting the project guidelines and driving the decision process, and an effective coordination mechanism among the developers based on shared communication protocols” (Bonaccorsi & Rossi, 2003, p. 1246). FrontlineSMS logs required constant monitoring to retrieve texts; some texts were never received. The response from the FrontlineSMS representatives in the discussion forum was “We know there are numerous problems with the software; Just wait for Version 2.” As app developers, we decided to direct participants to Twitter. Crowdmap developers via Twitter reported “there's a bug report for the issue mentioned on [GitHub link]- you can track progress here :).” This particular issue was fixed five months later; some issues remained unresolved. Our apps depended on whether the FOSS community of Crowdmap developers possessed the leadership to prioritize certain fixes or were intellectually stimulated to answer our prosaic questions. Crowdmapping supposedly induces greater empowerment via its technical fragmentation. If the ecosystem breaks and a CBO cannot put the fragments back together then it can imply a moral failure on the part of the CBO to effectively respond to the “move fast and break things” ideal of crowdmapping (Taplin, 2017). For funders, a CBO’s ability to fix the ecosystem could become a measure of its technical capacity and a measure of FOSS’s capacity to sustain the essential components.

Similar to Harris and Weiner’s (1995) analysis of PPGIS, crowdmapping ideologies both empowered and marginalized CBOs. Two CBOs with which we collaborated noted that crowdmapping enhanced their influence, allowing them to ‘punch above their weight class.’ Despite this increased capacity, our research found that app developers also had to become ecosystem managers, capable of surviving shifts in the network. As Brandusescu et al. (2016) pointed out, app management demanded new technical roles, including system administrators to maintain the app and geospatial data curators to interpret user-submitted data like SMS locations.

Despite exhortations that “FrontlineSMS provides the tools necessary for people to create their own projects that make a difference”, (Africa Journal in FrontlineSMS, 2009), we found that in our case studies in Canada (and North America), it did not. Our research in Canada showed that CBOs had little influence over the ecosystem to increase its stability and resilience. Stability is necessary for a CBO to make a difference, which in turn requires a degree of influence or control. This speaks to the essence of the ecosystem of decentralized and deconstructed mapping, which can generate a ‘view from nowhere’. Here apps and crowdsourced processes exist in the cloud, which implies that no one is influencing the ecosystem or that everyone is influencing it – it is somewhere 'out there' (Haraway, 1988).

Conclusion and Paths Forward

The crowdmapping ecosystem reflects a revolution in traditional ways of engaging the public, responding to crises, and developing technical solutions. Crowdmapping, because of its flexibility, inexpensiveness, ease-of-use and support from multiple actors, supposedly brings mapping power and justice to citizens via a locational technology. The rhetoric speaks of the intrinsic democratizing nature of a decentralized GIS, where anyone can modify and deploy the technology. In revealing the ecosystem, we found numerous problems with those promises, in terms of technical development, actor support, and larger ideologies (e.g., market, egalitarianism) embedded in the ecosystem. The ecosystem was and continues to appear fragile.

Since the research was conducted, the ecosystem has rapidly advanced in terms of new hardware, software, and data. SMS is far less popular now that data plans are less expensive and contributions can be made directly to the platform on one's smartphone. The crowdmapping ecosystem continues to see new intermediaries through new devices, browsers, platforms and actors. Far from a fleeting phenomenon, deconstructed mapping has become the standard. Numerous Javascript mapping libraries (e.g., Mapbox, Maplibre), which are not crisis mapping specific, enable relatively easy geoweb development. Paradoxically, platforms like Mapbox have the potential to recentralize disparate geoweb functions, essentially reconstructing GIS. Ushahidi Inc. has recently decided to use as its mapbase, Leaflet and Mapbox, which represents a re-assembling of multiple components.

Ushahidi Inc. now is partnering with 'Artificial Intelligence (AI) for Good' initiatives via Dataminr (Odongo, 2024), a data analytics firm that "helps companies get a head start and mitigate emerging risks" (Dataminr, n.d.). If generative AI was available at the time then we might have advocated for its use for coding and assembly by the developers of Crowdmap. We would have been more reluctant to advocate the use of generative AI to the CBOs we worked with because of existing computational skills within the organizations. Like promises of the geoweb, generative AI presumably renders knowledge of coding unnecessary, although knowledge of debugging, a part of traditional computer science learning, is essential if the generated code fails to work. Generative AI is itself an ecosystem of algorithms, data centres, policy regimes, and concentrations of power in Big Tech. AI contains its own set of biases, hallucinations, inaccuracies, and market-based ideologies promising democracy and freedom (Benjamin, 2019). Lessons learned from the old ecosystem can serve as cautionary tales for the AI-enabled ecosystem, for instance, from whom does a particular ideology originate in these seemingly objective technologies? How does one ensure stability with increasingly opaque components in the black box?

In addition to AI, we have witnessed the dominance of the platform economy and the monetization of VGI. Rosen and Alvarez León (2022) detailed how non-local platform actors like Uber, Zillow, and AirBnB shape a locality through their consolidation of power and control. These actors are non-local, resembling the original ecosystem of remote cloud services and contributors. These platforms are also bundled—reassembled into new black boxes—by private sector actors who use proprietary systems. Crowdmapping revealed a similar trajectory, where "Ushahidi embrac[ed] more proprietary facilities. In 2017, it integrated the Facebook Messenger chatbot into Uchaguzi to monitor the Kenyan election" (Gutiérrez, 2018, p. 131). With platforms, especially those supported by AI, it is difficult to foresee the impacts of these new black boxes and the sheer concentration of power in Big Tech (Whittaker, 2021).

With the proliferation of the platform economy, user contributed data has become a valuable commodity. Data can be sold and aggregated to data brokers (Lamdan, 2022), who represent an invisible new set of actors in the ecosystem. Besides expanding data brokers' datasets, community contributions to crowdmapping can be exploited as input to large language models, which are a part of the AI ecosystem. Communities must remain vigilant of the rapidly evolving extractive actors, although it may represent an unavoidable cost of those participating in the ecosystem.

Finally, we offer some recommendations to better stabilize the crowdmapping ecosystem. Referring to technical aspects, FOSS communities could be encouraged to improve end user experiences via refining the UI and creating standards. Those FOSS communities could ensure downward and upward compatibility that do not rely on technical expertise. One could develop metrics to assess the degree to which the FOSS communities communicate with end users of software. CBOs should be mindful of the bundle of technologies involved when engaging FOSS. Free is not always free; proprietary software may be best if there is no sustainable technical capacity. CBOs, researchers, and funders could develop metrics related to direct and indirect costs; however, we note that these instruments have limits (Brandusescu et al., 2016).

An app's success can be inversely proportional to the number of actors in its ecosystem. CBOs could decrease the number of actors with in-house development if it possesses the resources. Even then, CBOs remain dependent on Big Tech (e.g., cloud hosting, OSM, Mapbox). Certain actors may ideologically oppose stability. Stability essentially merges, eliminates, and black-boxes actors. However, a 'fail fast, fail often' motivation likely drives FOSS communities. A nonprofit with a stable funding arrangement would represent another example of a reduced ecosystem (Gruby et al., 2021). Should the nonprofit become an arm of the state, function as a for profit firm or yield to the aims of philanthrocapitalism, then that could increase stability, albeit at the cost of the public good. Our prescription is to continue to unpack the black box, to reveal the agendas, and ensure the original goals of the CBO.

Often local projects do not have a for profit business model and cannot scale, causing CBOs to hesitate in adopting the latest technology. Cisler (2005) found that funders often introduced specific technologies to groups who, in turn, could not support the costs, either in time or skills or money. We likely will see that AI increases fragility into the ecosystem. Funders should therefore resist introducing a technology just because it is innovative or FOSS or supported by a particular techie.

We focused on volunteer, low budget projects. However, many findings apply at any scale. As we have found, big and small nonprofits, even Ushahidi, are susceptible to the agendas of distant firms and the concentration of tech power. Ideologies follow tech power. Ecosystem dynamics can reinforce techno-libertarian values that prioritize individual autonomy and the market over collective action (Coleman, 2004; Fish, 2017). What happens when nonprofits hold redistributive values, viewed as deeply inefficient and opposed by the tech sector?

'Fail fast, fail often' may work for the tech community. Scaled-up and market-based philanthropy may work for funders. Yet CBOs likely should not embrace these mantras. All actors should acknowledge the limitations of a flexible ecosystem of many interlocking yet ultimately unstable components. The focus should be the problem and practical ways to solve it in collaborative efforts led by people on-the-ground, not just remote experts, techies or funders.

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