Utilizing Web-Based Public Participation Geographical Information Systems: Filling Gaps of the Marcellus Shale Natural Gas Industry

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ABSTRACT

An influx of natural gas extraction in the Marcellus Shale region of the United States presents serious environmental, public health, and social and behavioral health challenges to citizens, policymakers, enforcement agencies and industry. These challenges necessitated improved and more transparent data-sharing capacities between data 'owners' and data 'users.' FracTracker (www.fractracker.org) is a socially-networked public participation GIS formulated with the capacity to support both a knowledge collective and a geographical data mashup. FracTracker is a GeoWeb data repository focusing on the natural gas industry. This tool facilitates crowdsourced data and allows registered users to visualize the information as part of an empowerment design process. A concurrent storied-blog serves as the portal to the PPGIS tool, and synthesizes and translates data to further engage geographical and issue-based populations. The main features of FracTracker are the ability to blog and share drilling stories, upload and download geo-located data as various file types, visualize data onto basemaps, and save the visualizations as snapshots. FracTracker can be used to compare data and identify spatial patterns related to the shale gas industry to better understand the span of social, economic, land use, political, environmental, and public health considerations.

Key words: FracTracker - GIS - GeoWeb - Marcellus Shale - Natural Gas - PPGIS

1. INTRODUCTION

Background

With increased energy prices and improved extraction technologies, gas exploration in shale formations has increased across the United States in recent years [1]. The Marcellus Shale region underlies much of Pennsylvania, New York and West Virginia, and portions of Ohio, Maryland, Virginia, and Kentucky. Estimates of up to five hundred trillion cubic feet (500 Tcf) of methane and other gases may be trapped as a commercial resource within the Marcellus Shale [2]. Sixty percent of PA's land mass is within the PA's railroad, coal, iron and steel industries, as well as agricultural wealth, are a steadfast heritage [3]. As a result, this region shares an intimate relationship with industrial legacy. There are several other factors that have made PA a tempting area to drill, including: a lack of a severance tax imposed by PA regulation on the natural gas industry, economic climate, close proximity to the majority of shale gas consumers in the Northeast, a moratorium on drilling in New York state, and the promotion of domestic energy as an alternative to foreign sources. These factors are among the many that have contributed significantly to a proliferative growth of shale gas drilling in PA in the last five years.[1]

Drilling leases are obtained by gas drilling companies on an individual basis from mineral rights owners. Leases can be negotiated and vary appreciably. Although permits to drill are issued by the state, the burden of education relies upon the mineral rights owner (lessee). See Figure 1.

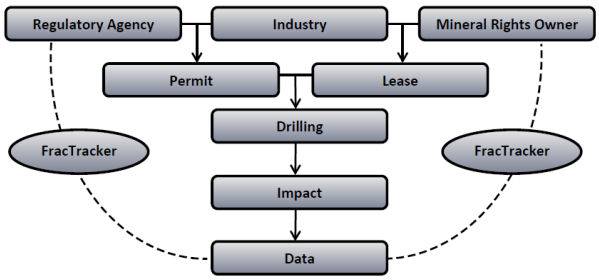

Figure 1. *The process of obtaining drilling permissions in PA, including data feedback loops. FracTracker intervenes primarily during the exchange of data between drilling, regulatory agencies, and mineral rights owners.*

Data Inadequacies

This burden on mineral rights owners (and regulatory agency decision making to some degree) is heightened

[1] For shale gas drilling (and hydraulic fracturing methods for the drilling process), see the following reference: [4]Delaware River Basin Commission. (2010, December 6, 2010). *Natural Gas Drilling in the Delaware River Basin*. Available: http://www.state.nj.us/drbc/naturalgas.htm

because data transparency and accessibility of industry and regulatory bodies is lacking in regards to shale gas drilling. The specific data gaps include: explicit location and time of certain gas industry operations, economic and social challenges (e.g. crime rates, traffic issues, and road degradation from heavy equipment), location and area of leased mineral rights, frequency of incidents (explosions, leaks, and blowouts), ecological impacts (e.g. how to obtain adequate amounts of fresh water for hydraulic fracturing without adversely affecting wildlife), emergency preparedness infrastructure requirements, and environmental health and public health impacts. There also exist significant accessibility challenges, such as:

- Dissemination of data originates primarily from authorized sources (top-down approach);
- There is a wide geographic scope of data and stakeholders;
- Spatial data infrastructure among regulatory bodies is inadequate for the public's use (e.g. electronic reporting of drilling data is currently not required [5, 6];
- Data and knowledge-sharing was not developed with non-experts in mind
- The industry's public relations campaigns did not focus on the experience of individuals.

These data gaps, accessibility obstacles, and the industrial expansion triggered concerns about the effects that shale gas drilling could have on public health, the environment, economy, and society.

Available Tools

New GIS have been touted to be an essential component of an informationally-enabled democracy [7]. Public participation GIS (PPGIS) was originally leveraged by grassroots organizations to help engage the public with the goals of improving transparency of and influencing policy change [8] PPGIS encompasses the participatory mechanisms involving the general public facilitated by GIS [9] and grounded by empowerment [10]. Geographical Web 2.0 basically encompasses the new approaches of self-participation through design, critique, and comments by Web applications. The content is adaptable, disseminated instantly, and provides a precision model for data correction, barring access and skill level [11]. Specifically, geographic information has benefitted not necessarily in terms of functionality, but in usability, accessibility, and ease of application development [12].

To address the data gaps and accessibility issues specific to natural gas drilling in the Marcellus Shale, a GeoWeb platform framed by specific topic and geographic extent was launched in June of 2010: FracTracker (www.fractracker.org)[2]. Figure 1 demonstrates the key data and information channels through which FracTracker intervenes. The following sections characterize the functional components of the FracTracker system framed by addressing the societal, industrial, and technological feedbacks that were initially identified by many participators concerned with the natural gas industry.

3. FRACTRACKER

Fundamentally, FracTracker is a data repository-linked GIS related to the shale gas industry provided at no cost to the user. A PPGIS assumes an intermediary. In this case, this assumption is fulfilled by researchers within the academic public health discipline; the development and management of this site relies partly upon researchers at the University of Pittsburgh's Graduate School of Public Health at the Center for Healthy Environments and Communities (CHEC). FracTracker assumes an acting management component that helps development and services being provided to the user in a flexible and efficient manner. This system, a socially-networked mapping tool, was formulated with the capacity to support both a knowledge collective (e.g., map-making, snapshot sharing) and a geographical mashup. The main components or tools within FracTracker area: a data repository, a Google Maps service interface, and a concurrent blog.

Database Repository

One of the main driving forces for the development of FracTracker was a lack of data availability and accessibility concerning the practices of the natural gas extraction hydrofracturing industry in the context of Southwestern Pennsylvania [13]. This is partly evident by the U.S. Environmental Protection Agency's long overdue life cycle analysis, which is projected to be complete in early 2011 [1].

In Pennsylvania, the natural gas industry is regulated by the PA Department of Environmental Protection (PADEP) – which among many of its roles supplies permits for drilling. The authorized data is 'public' data, though there remain many issues and blockades in the dissemination of this data as previously discussed. Drilling permits were the first piece of data that were found useful in analyzing the scope of this increasingly intensive industry.

[2] FracTracker is managed by the Center for Healthy Environments and Communities of the University of Pittsburgh Graduate School of Public Health, hosted by the Foundation for Pennsylvania Watersheds, developed by Rhiza Labs, and funded by the Heinz Endowments.

Availability of data in the Marcellus Shale region, let alone a data storage repository, was certainly a need expressed by scientific researchers, the public, governmental representatives, and environmental regulatory agencies based on the data gaps previously described. The repository was not envisioned as the optimum data source, given that spatially explicit data is a key criterion, but coincides with social constructivism.

Data and metadata can be imported in six (6) supported formats, which are then stored online within FracTracker:

- Shapefile + dBase (.dbf)
- Comma-separated values (CSV)
- KML – (formerly Keyhole Markup Language) OpenGIS KML Encoding Standard (OGC KML)
- GPX or GPS eXchange Format
- GeoTIFF – public domain metadata
- .XML FGDC (Extensible Markup Language Federal Geographic Data Committee) Metadata

FracTracker users continue to be challenged by the limits of the supported file types. The desire to better-support Microsoft Excel files has been discussed amongst the project's partners, especially for entering citizens' water quality monitoring data.

FracTracker is capable of data mashup via hyperlinked databases, which concurrently supplies a consumer mashup in the Google Map API. Registered user controls of published data include: extent of optional metadata beyond FGDC standards, attribute labels as search terms, column data types and description, ability to restrict dataset's visibility to 'anyone' or invitation-only groups, and the option to remove self-uploaded datasets. A registered user may download any of the openly visible datasets as: Shapefile, KML, or CSV formats. Once a dataset becomes part of the database, the user may save a dataset to a participating group, view/add comments, download, or visualize the data via Google Maps service application.

Google Maps API

The geographic web or GeoWeb describes the attachment of location-based geographic data with intangible information. A Web 2.0 platform, Google Maps, had shown to be successful in similar contexts, especially in disseminating data not just from authorized publishers, but also from volunteers or the public [14]. The Google Maps JavaScript API Mashup is a free service open to customization of the interface and the ability to add layered content to a map. Geo-referenced, -coded and -tagged data are beneficial and applicable in terms of the spatially inherent nature of the context:

- The drilling operations follow the underlying geologic strata containing the natural gas;
- Networked systems, such as sufficient roadways, must supply resources to the drilling locations;
- Topography is correlated with land use (e.g., drilling is preferred on flat or gently sloping terrain);
- Rural areas (e.g., farms, state parks, open spaces) present less obstacles for industry access;
- Access to freshwater for permitted surface water withdrawals must be considered; and
- There exist conglomerations of specific companies in certain areas (e.g., headquarters)

The Google Maps web mapping service application is referred to as the 'visualization tool' within FracTracker. Central to the visualization tool, is the Google Maps interactive map interface. Datasets (currently 119 at the time of publication) within the database can be added to the interface and visualized instantly through a definable query. Querying begins by selecting the desired data column, and depending on data type e.g., number; all unique values, a range of defined values, or as a graduated or linear spectrum, can be selected. Based on the selection, user-defined colors and symbols are customizable with the 'Style Picker.' There are no limits to the number of imported datasets and data values that can be visualized on the map. For instance, a geographic area may be represented by poverty rates from the US Census Bureau overlain by the National Hydrography Dataset flowlines, PADEP Marcellus drilling permits, Marcellus drilled wells, and environmentally-related violations administered to the industry by the PADEP. Geographically defined visualizations may then be published as 'snapshots,' which can be shared with other FracTracker users within the system or externally via RSS and other sharing networks (described below).

Snapshots are custom representations focused on a chosen geographic extent and utilize the location-based informational datasets within the data repository. These are live data connections, meaning that a snapshot will be automatically updated coinciding with the dataset. The snapshot may be manipulated by other users while within the system by performing the action of 'base a new visualization on this one,' and may re-published with additional datasets, new visualization styles, or critiques of descriptions. A 'share' button provides the direct coding to the snapshot. A snapshot may be shared by:

- Link – copying and pasting the snapshot's hyperlink into other applications or websites
- Embed – placing a live, clickable version of the visualization into a webpage
- Thumbnail – adding a static image of the snapshot with the optional legend
- KML – exporting the snapshot to other mapping applications, e.g., Google Earth,

NASA WorldWind, ESRI ArcGIS Explorer, Adobe Photoshop, and Yahoo! Pipes [15]

The geographic distribution of the participating public in this context, lends to the social network appeal, coupled with visual tools. The 'snapshot' therefore, is a user-created abstraction displaying unique data patterns and relationships that ultimately strive to tell and share a visual story. One example of this has been the dissemination of a snapshot showing current wells drilled in PA and a lack of adequate air monitoring stations.

Blog

An electronic social network in the form of a concurrent web log (blog) is tethered to the data and mapping tools, which serves as the data-to-information portal or front page. The blog collects and deciphers timely knowledge for the casual user supported by community-based participatory researcher (CBPR) contributors. The blog also adds incentive by posting 'snapshots' published by users developed with the FracTracker's mapping tool. Communities that are directly affected could be physically disconnected from casual relationships, because most drilling is occurring through private leases of land owners spread somewhat equidistantly from one another. As a result, there is a communication disparity between those affected by incidents and those who could most benefit from that information. The blog provides a forum to share this information that is less reliant upon geographic location as more traditional efforts. Much political, economic, social - and issues of the like - contribute to the feelings, knowledge, and beliefs towards this practice.

4. DISCUSSION

While, participation within FracTracker continues to grow steadily, with approximately 1,300 registered users in the first five months, active participation by repeat-use actors has been difficult to gauge. This can be party attributed to the complexity of the multi-component system as a whole – data repository, concurrent blog, and mapping tool. An acknowledged obstacle remains computer and internet access, as well as minimal GIS knowledge on the part of the user. CHEC is currently conducting a process evaluation with FracTracker's registered users to determine active participation and identify user interface issues.

This networked application should allow for a model that drives data perfection from the users by applying pressure on the publishers of the data, though this type of model remains contentious. There have been instances where FracTracker users have commented on locations of wells, regarding a location as: spatially inaccurate, not properly represented, or non-existent. There could be various explanations for these issues (e.g. non-natural gas well, improper data collection or management, inaccurately converted spatial precision).

A community should begin with a conversation, hence a social network. Empowerment through a creative design mechanism (e.g., making maps) can occur because the process in engaging and intimate. FracTracker should work in theory, though attracting and maintaining active participation does not always coincide. These aspects of group engagement remain difficult to evaluate. Nevertheless, the discourse within the network setting are substantial and should continue to be researched.

Future Considerations

The project partners and software developers continue to assess the needs of the system and its users. A GeoWeb platform by nature relies upon expediency and participation from both the technological and live communication standpoints. Although dependent upon adequate funding, these lines of communication will support the adaptability of FracTracker to reflect the variability of the issue, status of regulation, industry transparency, data characteristics, geographic context, and user profiles. Future considerations for the application of this tool include the following:

1. Continued introduction and implementation of FracTracker within communities of interest in the Marcellus Shale region (regulatory agencies, environmental monitors and organizations, citizens monitors, industry stakeholders, emergency responders, and policy-makers),
2. Data convergence from the communities of interest,
3. Improved user interface design – including a more user friendly data entry form,
4. Increased server space as database needs grow with increased user participation and data storage,
5. Indexing of datasets and snapshots for improved navigation and use, and
6. Continual evaluation of current and future needs.

A reoccurring motive in building GeoWeb applications is a lack of temporally-disseminated data to those who need it most. This stems from the limitations of insufficient and inadequate regulatory resources and a lack of precaution inherent in U.S. regulatory policy. Thus, overwrought interactions exist between the industry, the regulators, and the citizens, especially in a historically heavily industrialized area such as Southwestern Pennsylvania.

5. CONCLUSION

Open, interconnected GeoWeb systems should be utilized to help understand and localize related impacts of complex systems – such as the natural gas industry –

through Web 2.0 participation. Web-based social networks and data-sharing systems have displayed much success and growth in the prior decades, although it is warranted to critique them for their inability to reach all stakeholders and participants. The theory of a themed GeoWeb system focuses on data-to-information translation for capacity building by leveraging the immense benefits of a spatial component [16]. An appropriate GeoWeb participatory system must dynamically reflect the topic of concern while attempting to identify the public's and stakeholders' interests [17]. FracTracker promises to improve shale gas data and information sharing among its users through an empowerment design process. GeoWeb systems help to visually harmonize data and information, while also providing a voice for the system's participators – in effect, driving data and information progression.

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