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Cartoforum – A Map-Based Discussion Forum with Applications in the Planning of Cycle Lanes, Community Food Gardens and Campus Sustainability

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Abstract

Map-based discussion forums can be used for crowdsourcing people's ideas and opinions with respect to public planning processes. Their volunteered geographic information consists of text and other media that are linked to geographic features. Building on the concept of argumentation mapping, Cartoforum was developed using the Boundless geostack, an open-source geospatial software package. We present the software architecture and functionality along with three pilot studies covering cycle lane planning in Toronto, Canada; community garden site-selection in the Toronto region; and campus sustainability at the University of Kerala, India. Together, the pilot studies demonstrate the utility of argumentation mapping and illustrate the range of its potential applications in citizen participation.

Keywords:

argumentation mapping, public participation GIS, campus sustainability, community gardens, cycling infrastructure, volunteered geographic information

1 Introduction

'Argumentation mapping' is defined as the combination of a discussion forum and a map (Rinner, 2001). The concept extends Geographic Information Systems (GIS) in a number of important ways. An argumentation map facilitates the interaction of multiple users and requires a distinct data model. In standard GIS, spatial objects have a fixed number of numerical or categorial attributes. Meanwhile, extended text and other media do not easily fit within the GIS data model. In argumentation maps, the connection between 'attribute' and spatial object is more flexible: one can exist without the other. Going beyond simple map annotation, an argument can reference multiple objects, and an object can be referenced by

multiple arguments. The arguments or posts submitted by participants can be viewed as Volunteered Geographic Information (VGI).

Tools and platforms with core argumentation mapping functions, often termed Public Participation GIS (PPGIS), include Geolive (Corbett & Cochrane, 2017) and GeoKey (Roick et al., 2016), and the defunct Argoomap (Sani & Rinner, 2011), Mapchat (Hall et al., 2010), and GeoDF (Zhao & Coleman, 2006). These platforms have a common goal of using widespread internet connectivity to enable distributed groups of stakeholders to capture, combine and share place-based knowledge (Corbett & Cochrane, 2017). The idea of 'citizens as sensors' was put forward by Goodchild (2007). Local observations by a non-expert 'presumably reflect the lived experience of an individual who "knows" a place well' (Sieber & Haklay, 2015). These stakeholders, or the 'crowd', are 'imagined as being representative of citizens for whom the issue at hand is relevant', while 'the data points and products of participatory mapping projects are not a reflection of all members of society' (Corbett & Cochrane, 2017, p. 2).

As a localized, limited-time, collaborative mapping effort (Roick et al., 2016) requiring active participants, argumentation mapping tends to engage a smaller number of participants (Fast & Rinner, 2018; Haworth, 2018). This, along with the meta-analysis of similar 'research cases' by Sieber et al. (2016), contrasts with research into the handful of global crowdsourcing projects such as OpenStreetMap (e.g., Haklay, 2010; Scholz et al., 2018), and passive, sensor-based crowdsourcing, often from social media (e.g., Steiger et al., 2016), which is based on much larger participant counts.

Most collaborative mapping applications require a separate instance to be deployed for each user group. In order to start a new group, the organizer needs to install the source code on a web server and customize the application for the purposes of the group. This level of advanced web development creates a significant barrier. Nor do the existing solutions incorporate the flexible mapping functionality, argumentation functionality or data-browsing options that characterize argumentation maps (Rinner, 2001) or PPGIS (Mukherjee, 2015). For example, they do not support either geographic features other than points, or replies linked to new features.

The present research aimed to implement concepts of argumentation mapping into a generalized software platform that inexperienced users can use without training. We set out to develop an online map-based discussion forum that incorporated the following features:

- unlimited users, groups and user-group membership
- easy group setup and management
- mapping functionality extended to point, line and polygon features
- data-browsing functionality extended to search by text, geography, user and discussion thread
- unlimited reply functionality with the ability to link replies to new geographic features

- voting system for rudimentary decision-making
- dynamic styling system for map objects linked to activity in the conversation.

The platform was developed based on principles outlined in previous research. It required a novel data model and frontend that are usable for a wide range of possible map-based discussions. A preliminary evaluation of the platform was conducted using naturalistic use cases similar to assessments of Geolive (Corbett & Cochrane, 2017) and GeoKey (Roick et al., 2016). The present pilot studies were analysed using the VGI systems approach (Fast & Rinner, 2014), which explicitly takes into account the participatory project context, its participants and the Geoweb infrastructure, as well as the data input, management, analysis and presentation functions employed.

The remainder of this paper describes the open-source architecture and functionality of the Cartoforum application and the results of three pilot studies. In the pilot studies, the platform was tested by the public and by two student groups in Canada and India to discuss cycling infrastructure, community food gardens and campus sustainability, respectively. The paper compares the pilot studies and concludes with a summary of findings and outlook on future research and development.

2 Cartoforum

2.1 Open-Source Architecture

The Cartoforum server runs a Linux operating system, the Boundless geostack made up of PostgreSQL with PostGIS, Geoserver, and a REST API written in Python using the Flask microframework. All of these components and the user interface communicate omni-directionally (see Figure 1) to facilitate database outputs, processes and loads. Geoserver reads data from the PostgreSQL database and generates map tiles. The Flask API reads the database to respond to user requests. The user interface communicates with Geoserver via the Web Map Service (WMS) protocol to request map tiles. Tomcat and Apache are the web servers for Geoserver and the user interface, respectively. The user interface is written in JavaScript, and maps are rendered using OpenLayers. Base map options include OpenStreetMap, CartoDB and Bing. The database schema, which is specific to argumentation mapping, includes tables for threads, posts and map objects. Posts are created within threads and are identified by a unique ID, the authoring user and date. If the post is a response to a previous post, then the original post's ID is also stored. If the post is linked to a map object, the object's ID is stored with the post. Multiple posts can reference the same map object. Posts and objects can exist without being referenced by each other. This schema allows an unlimited amount of unstructured information to be linked to a feature without compromising database integrity. Map objects are identified by a unique ID, author and creation date.

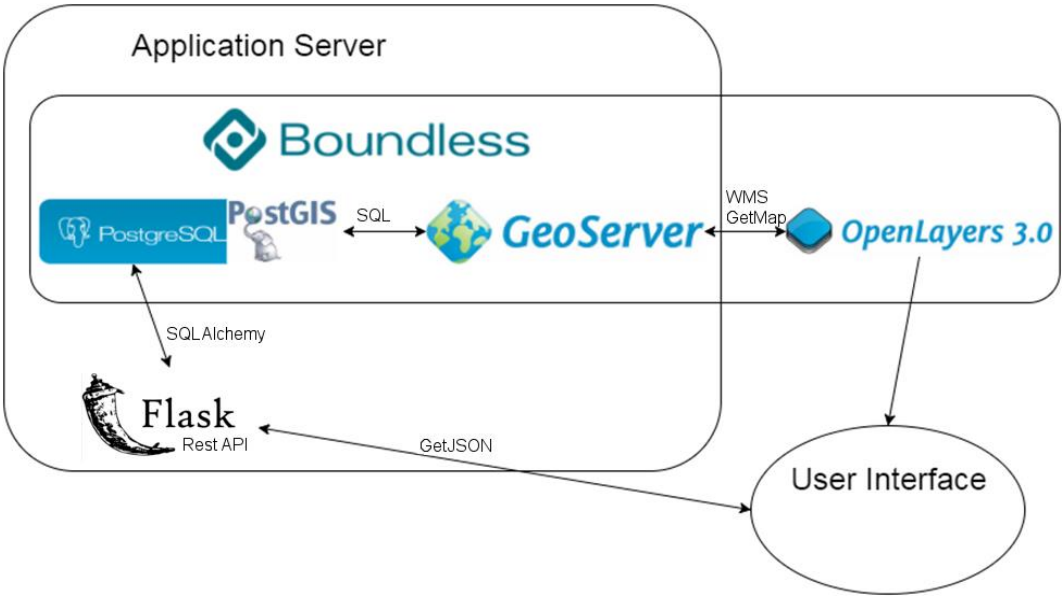

Figure 1: Overview of Cartoforum's application architecture.

Account creation is facilitated through OAuth, an authentication protocol to verify a user's identity via another social-media login such as Google or Twitter. Users can thus log in without having to create a new password, provide their email, or use a CAPTCHA. In-app account-creation is also possible by clicking on a 'Create Account' button on the homepage. Emails are not required to create an account and are used only to allow users to reset their password.

In the database, users are identified by a unique ID and username. Groups are identified by a unique group ID and name, with an administrator as the first group member. Individual users may belong to an unlimited number of groups. The group database table also stores geographic boundaries, centroid, and whether or not the group allows open membership.

2.2 User Interface and Viewing of a Discussion Thread

The application interface (Figure 2) is divided into a header with data-browsing tools and map style controls, a sidebar where posts are displayed, a map canvas, and a footer with logout and attribution information. The header contains controls to filter posts by thread or user, limit posts to those that are linked to objects in the map extent, a search box to filter posts by search text, and controls to select the base map and set the style of the contributed map objects.

Content in the sidebar is dynamically generated based on user inputs and filters. The title of the thread that is active is at the top, with instructions on how to add a new post to the thread. Posts which are selected are highlighted in yellow. Each post in the sidebar has a

button to zoom to the related map objects, shown as a magnifying glass. There are buttons to reply and vote; upvote and downvote buttons are illuminated if the user has already cast a vote for or against the post. This area also shows the current vote total for that post. The group administrator can see all posts in order of vote tally in the administrative interface. When a user clicks on a map object, only posts associated with that object are shown. Conversely, when a post in a thread is clicked, the corresponding objects are highlighted on the map.

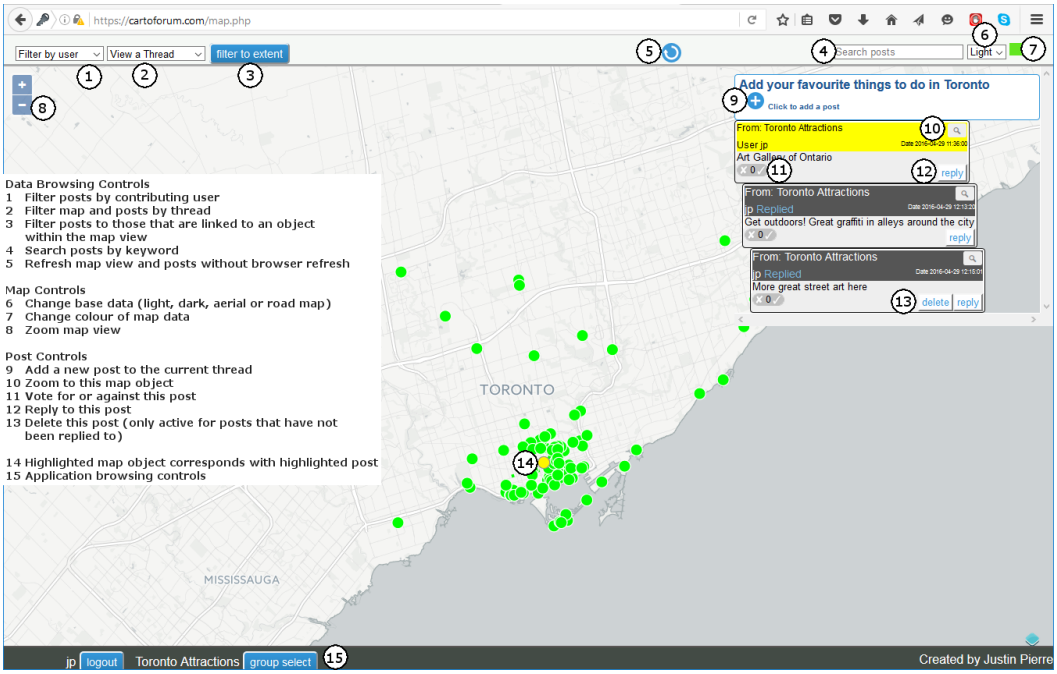

Figure 2: Cartoforum's user interface.

2.3 Group and Thread Creation and Posting

A user who creates a group is designated as that group's administrator. This enables an 'admin' button next to the group title via which the administrator can access an administrative panel, invite new users, view all threads within the group, close threads, view the responses to threads and their vote tallies, remove users from the group, and add spatial datasets immediately. They can also delete the group entirely, wiping out all user relationships and contributed data. Growth of the user-group network is encouraged by making it easy to invite new members by email, browse existing groups, and request invites to groups. Threads are created within groups to organize posts into topics or discussions. Each thread has a unique identifier, a short name, a descriptive name, and a flag to indicate whether the thread has been resolved or retired from further discussion. These flags are controlled by the group administrator.

Users need to create or select a thread before they can contribute a new post. They can select a thread in three ways: by choosing from the drop-down in the top bar, by clicking on a post in the sidebar, or by clicking on a map object. Clicking on a post or on the map will bring up the related thread(s). Once a thread is selected, a button in the thread's title prompts the user to add a new post. The user can then enter their post and choose how to link the post to a geographic feature. They can create a point, line or polygon; or they can link their post to an existing map object; or they can choose 'none' to create a post that is not linked to any geographic feature. The user is also able to edit the object that they are in the process of creating. Once the user clicks 'save', the post and map object are committed to the database and linked together with the object ID. As long as the post has not been replied to, its creator is able to delete it.

3 Pilot Studies

3.1 Toronto Bicycle Network Pilot Study

Toronto has an active cycling community. There is an ongoing conversation about expanding a safe cycling infrastructure to accommodate the needs of the public for commuting and recreation. The city is working to connect the non-contiguous cycling network through efforts like the Cycling Network 10 Year Plan, which identifies 525 km of new cycling infrastructure to be introduced between 2016 and 2025 (Pucher & Buehler, 2005; City of Toronto, n.d.).

In this pilot study, Cartoforum was examined for its efficiency and effectiveness. Efficiency was measured as the number of users that interact with the application after account creation. Effectiveness was measured by the extent to which users make use of the ability to link geographic features with posts, defined as the 'utility ratio' or number of posts linked to a map object divided by the total number of posts (Sidlar & Rinner, 2009). The total number of potential linkages is the same as the total number of posts. The utility ratio was calculated for all posts as well as for original posts and replies.

This was a naturalistic, unassisted user group, in which users were not primed about how the application works. 'Naturalistic' refers to using an existing situation and passively assessing the outcome of the users' interaction with the platform. Users based their interaction on existing knowledge or opinions about public infrastructure and used the platform to express themselves about a real situation. They were encouraged through a brief text prompt to provide their thoughts on potential improvements to cycling infrastructure in the City of Toronto based on a map of existing cycle lanes and the underlying road network. The text prompt read: 'This is a collaborative, crowd-sourced map for bike infrastructure. See existing bike lanes (Green) and suggest new ones (Blue). To suggest a lane, vote or comment: Login or Sign up.'

The group had open and unlimited membership. It was publicly visible, but contributions, voting and some data-browsing tools were only available once the user had created an account and logged in. Members were recruited by promoting the group on social media such as Twitter, LinkedIn and Reddit, as well as to cycling advocacy groups. The application interface showed a base map of the City of Toronto with existing cycle lanes as of January 2016 (collected from the Toronto Open Data Portal, 2016) styled in green, and user-contributed cycle lane improvements styled in blue. Attribute data regarding status as a lane shared with traffic, separated bike lane, or cycle path were shown as an administrator's post linked to the object. A legend explained the meaning of the two styles (green and blue). When a user started to create a post, the geographic feature type defaulted to line, but users had the option to create any type of map object or to create a post without geographic reference.

3.2 Oshawa Community Gardens Pilot Study

Community gardens improve community health through nutritional and physical activities (Kortright & Wakefield, 2011), promote climate-smart food systems (Newman, 2008; Schneider & Fast, 2017), and foster positive social interaction and community engagement (Levkoe, 2006; Rosol, 2010). The Oshawa Environmental Advisory Committee, as part of the City Land Inventory Pilot Project, partnered with a second-year Geographic Information Science course (41 student participants) to explore the suitability of surplus land to serve as temporary or permanent community gardens.

The suitability assessment had two parts: an individual component and a collaborative one. First, students were tasked to identify suitable sites individually. The assignment involved elements of GIS project management, requiring the students to consider various inputs (e.g., the Community Garden Procedure Guide published by the city), management, and presentation components, in addition to a GIS-based analysis (constraint mapping). Based on each student's three top sites, the students then collaborated online using Cartoforum to negotiate and come to an agreement on the five most suitable community garden sites for the city.

The collaborative session was conducted as an assisted experiment held during a two-hour computer lab period. All students logged in to Cartoforum and accessed the Oshawa Community Garden group with a map of the City of Oshawa and existing park boundaries. The instructor gave a walk-through of the Cartoforum interface. Then, students entered their proposed community gardens as polygons. During this time, two assistants answered student questions. Once the individual data entry was completed, students broke into small groups to discuss their individual criteria for picking their top three sites, and then deliberated optimal conditions for a new community garden location. After the small-group negotiation, students returned to Cartoforum to vote on the top garden sites. The end result was a collaborative dataset of all proposed gardens, which could be ranked according to numbers of votes and comments to determine a final ranking.

3.3 University of Kerala Sustainable Campus Pilot Study

According to the International Sustainable Campus Network (2011), infrastructure development of a university campus should take into account academic, aesthetic, environmental and sustainability concerns. The pilot study was conducted at the University of Kerala, southwest India. The University is planning infrastructural development of Kariavattom campus to raise it to 'campus of excellence' and international standard.

The pilot study was conducted in two phases. In the first phase, 10 graduate students with GIS backgrounds were given a classroom demonstration of Cartoforum. Based on their feedback, a second phase of user testing was conducted with a more diverse group. Invitations along with a Cartoforum tutorial were sent to students, professors, office staff and engineers within the university community who had varying Internet, Geoweb and GIS skills.

This group was active from April to June 2018. The participants were asked to discuss sustainability ideas for the university campus. To initiate discussion, the moderator posted topics related to sustainability. Figure 3 shows a screenshot of the discussion group and the associated threads.

The content of contributions was used to assess the quality of the discussion. Participants' feedback on the user-friendliness of the tool was collected through a questionnaire, which included basic information regarding their age and familiarity with Google Maps, social media and GIS.

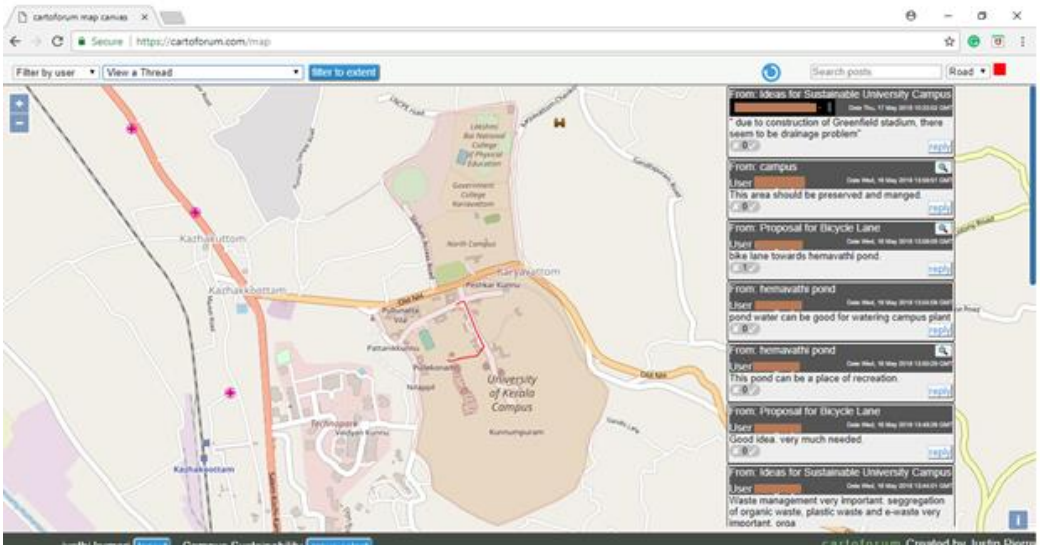

Figure 3: Screenshot of the Campus Sustainability group on Cartoforum, with anonymized usernames.

4 Results and Discussion

4.1 Comparison of the Bicycle Network and Community Gardens Pilot Studies

The Toronto cycling group had 43 members and 51 posts, of which 18 were replies to posts from other users. Twenty-four of the users in the group (47%) created a post; 19 created an account but did not write a post. Users were also able to contribute to the conversation by voting for or against a post from another group member. Forty-seven votes were cast by 23 group members. In total, 35 users participated by either posting or voting, resulting in an overall participation rate of 81%. In this group, the utility ratio was 63%, consisting of 85% for original posts and 22% for replies.

The Oshawa gardens group generated 102 posts, of which 30 were responses to original posts. Thirty of the 41 users in the group (73%) created a post. There were 75 votes cast by 28 members, and 38 users participated by either posting or voting, resulting in a participation rate of 93%. The utility ratio for this group was 65% – 82% for original posts and 21% for replies. With some overlap in proposed garden sites between participants, there were approximately 20 proposed garden locations.

Since the unassisted group (Toronto cycling) had an almost identical number of user accounts as the assisted group (Oshawa community gardens) and a similarly high participation rate, the Cartoforum platform can be considered successful in enabling map-based argumentation. The utility ratios for the two groups for both original posts and replies were nearly identical, indicating that untrained users were able to understand how to link their posts to map objects. Based on these utility ratios, the application can be deemed effective as an argumentation map.

The observed utility ratios are significantly higher than those seen in earlier studies (e.g. Sidlar & Rinner, 2009). This may be a result of the topics of the groups: suggesting cycling lanes and community gardens requires explicit references to map locations. It may also have to do with the design of the user interface. When a user tries to create a post, the application prompts them to draw something on the map. If they do not wish to do so, they must make a conscious choice to select 'no geography' before they can save their post. Sidlar & Rinner (2009) also note that the utility ratio for replies is typically much lower than for original posts. This is because the reply is intrinsically linked to the map object created in the original post. Very often, the replying user is providing further comment on the same geography. However, for the purposes of this analysis these replies were considered to be aspatial.

In the cycling group, some users employed the ability to reply with a link to a new geographic feature as an alternative to another user's proposal. For example, one user suggested a cycle route through Riverdale Park by the Don Valley Parkway between Danforth Avenue and Gerrard Street, reasoning that this connects two existing lanes. Another user replied and suggested an alternative route down Broadview Avenue, reasoning

that this would avoid the steep inclines required to cycle into and out of the park. Users also replied with geographic features to expand previous suggestions and make arguments for extending their suggested cycle lanes further.

The community gardens group used this feature in different ways. Some users linked all of their own suggested garden locations together as a series of replies. In this way it was easy to browse their suggestions as a single thread. Other users replied to their own suggested garden location with justifications for their selection, pointing out bus stops, schools or community centres in the area. This group also made use of non-spatial replies to point out mapping errors.

4.2 Evaluation of the Campus Sustainability Pilot Study

In the second phase of the University of Kerala pilot study, a total of 14 participants registered with the Cartoforum application. Ten users accepted the invitation to participate in the campus sustainability discussion group. Out of these, 8 participants actively contributed to the discussion, for a participation rate of 57%.

Pertinent threads were posted by the participants (shown in Figure 3), but only some of them made use of the GIS functions to create spatial references for their posts. The discussion messages indicated that the participants had a general understanding of sustainability concepts. The general topic for discussion initiated by the moderator included 'Ideas for Sustainable Campus'. To kick-start the discussion, the moderator started threads about sub-topics such as waste management, energy management and campus cycle lanes. Interesting ideas shared by the participants included, for energy management, the installation of low-maintenance solar panels on building terraces to reduce energy costs, and the promotion of aquaculture in the campus pond.

The performance of the application was evaluated using a simple questionnaire. General remarks about the tool and suggestions for improvement were also requested. Six participants provided feedback. They found the GUI somewhat difficult to understand and suggested that more information and a help menu should be provided. Creation of a user account and understanding a discussion topic were reported as easy. Starting a new thread and replying to a thread were easy for half of the respondents. Creating a map object, however, was difficult for most participants. Additional suggestions from the participants included added functionality such as language options, photo upload, and marker symbols like those in Google Maps. In general, participants did not understand GIS terminology such as creating a point, line or polygon, although they understood markers and the area of a polygon.

5 Conclusions and Outlook

The development of Cartoforum aimed at providing a scalable software platform with an intuitive user interface and advanced collaborative functionality. The data model allows different users in a group to communicate with each other while linking posts to a map object. In the Canadian pilot studies, users with and without assistance were able to understand this feature and use it effectively. The user interface was successful at encouraging users to participate in the groups and submit VGI.

The pilot study at the University of Kerala, India, revealed some challenges for users, which may in part be explained by language barriers, despite the English-language university environment. In theory, participatory Geoweb applications such as Cartoforum could be very useful in India, because the country is transforming and digital technology has the potential to bridge the gap between rural and urban India. If language options could be included, Cartoforum would have wide applicability in areas such as rural planning, farm supply-chain management or disaster preparedness, although it must be noted that information and communication technology projects in India 'tend to benefit those who are already in a relatively privileged position' (Choudhary, 2012, p. 4).

Overall, Cartoforum supports efficient collaboration in spatial conversations that goes beyond simple annotation functions available within existing online mapping platforms. Cartoforum implements a novel way to browse spatial-conversational connections. The application has potential uses in community planning and citizen science, although PPGIS tools developed for use with one population may not be adaptable to another population due to technological differences (Sieber, 2006). In order to overcome this difficulty and to foster sustainable uptake, the Cartoforum source code and documentation were released on the GitHub developer community site. The open-source code can be adapted for use in specific cases, while the hosted site remains available to users without the technical capacity to install and/or adapt the application.

As a public consultation tool, Cartoforum may be hampered by its online nature. Adoption by rural or remote communities may suffer from internet access limitations. The problem of the 'digital divide' extends to socio-economic and demographic factors that may limit groups' meaningful online participation (Laituri, 2003; Sui et al., 2013). However, the fact that the platform does not make use of any special software or significant client-side processing power may be an advantage in these areas, as it would still be accessible on older computers over dial-up internet.

Additional data management tools such as measurement of distance or area, thematic mapping and group analytics should be developed as additional modules that group administrators can enable as needed. Some groups may require that their data be private, and such a security feature should be added to the 'groups' table of the database. It should also be possible to add a detailed description of the group's purpose and objectives, and to define a participation period with start and end dates. Further development could include the ability

for administrators to download all spatial and conversational data related to their group for analysis in desktop GIS or sharing in some other form.

Argumentation mapping still presents an uncommon, highly specialized web 2.0 application. Quasi-standard Geoweb platforms such as Ushahidi/CrowdMap and Google Maps can be adapted for use as argumentation maps but require custom-programmed functionality or manual entry of conversational linkages and conversation-browsing. In previous research, we found that using a standard development platform such as Google Maps made some functions of Geoweb tools (e.g. map viewing) more user-friendly thanks to prior user experience, while it resulted in a dependence on the software updates and licence changes of the platform (Rinner et al., 2008; Sani & Rinner, 2011). The pilot studies presented in this paper benefit from Cartoforum's unique characteristics and demonstrate the utility of a specific type of VGI for planning in communities and larger organizations. As an asynchronous, distributed collaboration tool, it can complement conventional forms of participation such as synchronous, face-to-face public meetings or asynchronous, distributed mail-in submissions.

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