The tools of citizen science: An evaluation of map-based crowdsourcing platforms

ZACHARY LAMOUREUX
Department of Geography
University of Calgary
zjjlamou@ucalgary.ca

VICTORIA FAST
Department of Geography
University of Calgary
victoria.fast@ucalgary.ca

1. Introduction

There seems to be a persistent yet inaccurate sentiment that collecting vast amounts of data via citizen science is virtually free, especially compared to the cost of privatized scientific endeavors (Bonney et al., 2009; Cooper, Hochachka & Dhondt, 2011). However, performing scientific procedures with the assistance of the public is often far more complex than traditional scientific enquiry (Bonter & Cooper, 2012).

Citizen science promotes the participation of the public in scientific endeavors (Hecker et al., 2018). While citizen science is not synonymous with volunteered geographic information (VGI)—broadly defined as the creation of geographic information by citizens (Goodchild, 2007)—it often produces geographic information. Similar to VGI, citizen science projects tend to follow specific protocols to ensure the crowdsourced geographic data serves as an input for (scientific) research (Haklay, 2013). Also similar to VGI, citizen science projects often require software applications and specialized training to facilitate citizen data collection. Notably, citizen science projects are increasingly requiring a web-based participatory mapping platform—i.e., Geoweb (Leszczynski & Wilson, 2013)—to coordinate the proliferation of citizen contributions.

Many scientists, researchers, and especially geographers, have developed their own platforms to facilitate the capture, management, and sharing of citizen science contributions. Notable examples include Geolive (Corbett & Cochrane, 2017), GeoKey (Roick, Haklay, & Ellul, 2016), and Argumap (now Cartoforum) (Rinner, Kumari, & Mavedati, 2011; Sani & Rinner, 2011). These platforms "provide an online space for collective place-based knowledge, experience and wisdom to be captured, shared, exchanged, contested and negotiated" (Corbett & Cochrane, 2017, p.2). However, these map-based data platforms are often developed with significant financial expense, time investment and risk tolerance (Bonney et al., 2009). It is unrealistic to assume that the developers of every geographic citizen science project will have the time, capital, and technical skill necessary to develop their own platform.

As an alternative to in-house developed tools, there are several commercial and open-source online mapping platforms dedicated to crowdsourcing data that could be useful to individuals starting citizen science projects. These tools have been developed with two key features: a front-end user interface, and a "sign up and go" back-end to enable the creation of a project or deployment by anyone. No app development or programming is required for the person initiating a project.

In this research, we investigate publicly available commercial and open-source map-based tools that enable citizen science projects. Building on a comprehensive comparative framework, we

conduct a systematic evaluation and overview of five map-based crowdsourcing platforms: Ushahidi, Maptionnaire, Survey123 (ArcGIS Online), Open Data Kit, and GIS Cloud. These tools have additional uses that extend beyond the field of citizen science; however, the scope of the investigation was narrowed to focus on aspects most suitable for citizen science endeavors, such as the collection, management, visualization and dissemination of crowdsourced data. It is our intention to provide information on how these publicly available crowdsourcing platforms suit generic geographic citizen science crowdsourcing needs.

2. Methods and Data

2.1 Platform Selection

Three of the selected platforms (Maptionnaire, Survey123 and GIS Cloud) are commercial tools, while Open Data Kit is an open-source application. Ushahidi is commercially available through their website, however it can also be found as an open-source application on GitHub. The commercial version of Ushahidi hosted on the web was explored in this investigation. Our five platforms were chosen based on meeting the following conditions: the platform enabled crowdsourced contributions, has a map-based interface, is web-ready (i.e., no server install required), and has some free functionality.

Citizen science has been performed by birders for over a century (Silvertown, 2009), so we chose to run a mock ornithology project to streamline the comparison, ensuring each individual platform evaluation was consistent and impartial. However, all the functionality from each platform was fully explored; the thoroughness of the comparison was not limited by the mock ornithology project.

For each platform, we signed up and started a project called "Calgary Ornithology Survey". Once the back-end was set up, we explored the site's data collection tools (web surveys and mobile applications). The final step was submitting the ornithology dataset

from the public interface (the front-end). The fifteen entries consisted of four types of birds (Table 1).

Table 1: The fifteen data points used in the mock survey. All fifteen are located within the city limits of Calgary, Alberta.

Entry #	Type of Bird	Location
1	Robin	Parkland
2	Robin	Southcentre
3	Robin	Chinook Centre
4	Eagle	Trico Centre for Family Wellness
5	Eagle	University of Calgary
6	Chickadee	Rocky Ridge YMCA
7	Chickadee	Saddledome
8	Chickadee	Calgary Tower
9	Chickadee	Southern Alberta Institute of Technology
10	Blue Jay	Mount Royal University
11	Blue Jay	Southland Leisure Centre
12	Blue Jay	Market Mall
13	Blue Jay	Fairview Arena
14	King Fisher	Cranston Sobeys
15	King Fisher	YYC Airport

2.2 Evaluation Metric

These investigations followed a specific evaluation metric that tested the same features and functionality of each platform. This evaluation metric was based on a similar one established by Fast and Hossain (under review) in their evaluation of WebGIS platforms and includes the categories introduced in Table 2.

Citizen science terminology has been a topic of debate in recent years, with different groups of individuals deriving different meanings from the same terms (Eitzel et al., 2017). This study considers users and participants as non-professionals participating in a citizen science program. Authors and administrators are defined as

the individuals that create and operate the citizen science project.

Table 2: The Evaluation Metric, displaying major categories and evaluating criteria that guides the investigation of the platforms.

Evaluation Metric		
Major Categories	**Evaluation Criteria**	**Description**
Data Input (front end)	Data input types	The types of data that can be collected.
	Data collection options	How data is posted on maps by surveys and/or mobile applications.
	Data collection software	Software that supports the data input.
Data Management (back end)	Built-in dataset availability	The data supplied by the platform.
	Import data options	Options to import pre-existing datasets.
	Edit options	The ability to edit the collected data.
	Export options	The ability to export the collected data.
Data Analysis	Geoprocessing options	Specific tools that allow the author to buffer, clip and aggregate, amongst others.
Data Visualization	Data view options	How the data is displayed on the platform.
	Map publishing options	How a map can be shared and made publicly available.
	Default base map options	The number of available unique base maps.
	Symbology and labelling options	Map customization options.
	Widget options	Availability of customizable software applications.
Associated Costs	Paid options/Upgraded versions	Incurred costs of operation and software downloads.

3. Results

The results of the evaluation of the crowdsourcing platforms are organized by data input, management, analysis, visualization, and associated costs. The components are summarized in Table 3.

3.1 Data Input

Each platform collects data via surveys, and only Ushahidi offers data collection via SMS and email. The data input types differ for each platform and Maptionnaire is the only platform that does not offer a date or time field. This is a significant downside to the platform since the date and time fields could be crucial to a project.

Ushahidi data can be collected via the web and Android devices. Maptionnaire is entirely web-based while Open Data Kit and GIS Cloud are based on mobile applications for data collection (although GIS Cloud apparently does offer web data collection for their true crowdsourcing services). The Open Data Kit Collector application is available for download solely on Android devices, which severely limits public access to the survey and its data. Survey123 is the only platform to offer web surveys and mobile applications that support both Android and iOS devices.

3.2 Data Management

Survey123 and GIS Cloud offer built-in databases, the others do not. Every platform save for Open Data Kit allows data imports (paid option in Ushahidi), with each

platform supporting different file formats. Data edit and delete options are available in each platform, however in Maptionnaire only the editing of single data points is free. Survey123 is the only platform that

Table 3: Summary of the options provided by each platform.

	Evaluation Criteria	Ushahidi	Maptionnaire	Survey 123	Open Data Kit	GIS Cloud
Data Input (Front End)	Data Collection options					
	- Surveys	Yes	Yes	Yes	Yes	Yes
	- Email	Yes	No	No	No	No
	- SMS	Yes*	No	No	No	No
	Data input types					
	- Points	Yes	Yes	Yes	Yes	Yes
	- Lines	No	Yes	No	Yes	Yes
	- Polygons	No	Yes	No	Yes	Yes
	- Text	Yes	Yes	Yes	Yes	Yes
	- Numbers	Yes	Yes	Yes	Yes	Yes
	- Addresses	Yes	Yes	No	No	No
	- Photos	Yes	Yes	Yes	Yes	Yes
	- Videos	No	No	No	Yes	No
	- Audio files	No	No	No	Yes	Yes
	- Date	Yes	No	Yes	Yes	Yes
	- Time	Yes	No	Yes	Yes	Yes
	- Website URLs	No	No	Yes	No	No
	- Video links	Yes	No	No	No	No
	- Barcodes	No	No	No	No	Yes
	Data collection software					
	- iOS	No**	No	Yes	No	Yes
	- Android	Yes**	No	Yes	Yes	Yes
	- Web	Yes	Yes	Yes	No	No
Data Management (Back End)	Built-in dataset options	No	No	Yes	No	Yes
	Import data options	Yes*	Yes	Yes	No	Yes
	- CSV	Yes	No	Yes	-	Yes
	- Shapefile	No	Yes	Yes	-	No
	- TXT	No	No	Yes	-	No
	- GPS exchange format	No	No	Yes	-	No
	- GeoJSON	No	No	Yes	-	No
	- Map layers	No	Yes	Yes	-	No
	- Custom base maps	No	Yes	Yes	-	Yes
	- XLS	No	No	No	-	Yes
	Data edit/Delete options	Yes	Yes*	Yes	Yes	Yes
	- Remove single faulty data entry	Yes	No	Yes	Yes	Yes
	- Mass delete data	No	Yes*	Yes	No	No
	- Sort and filter data	Yes	Yes*	Yes	Yes	Yes
	- Edit single data points	Yes	Yes	Yes	No	Yes
	Export options	Yes	Yes*	Yes	Yes	Yes
	- CSV	Yes	Yes*	Yes	Yes	Yes
	- Excel	No	No	Yes	No	No
	- KML	No	No	Yes	Yes	Yes
	- File Geodatabase	No	No	Yes	No	No
	- Shapefile	No	Yes*	Yes	No	Yes
	- MapInfo	No	Yes*	No	No	Yes
	- JSON	No	No	No	Yes	No
	- DXF	No	No	No	No	Yes
Data Analysis	Geoprocessing options	No	Yes*	Yes	No	Yes
Data Visualization	Data view options					
	- Map view	Yes	Yes*	Yes	Yes	Yes
	- Graphs	Yes*	No	Yes	Yes	No
	- Timeline view	Yes	Yes*	Yes	Yes	Yes
	Map publishing options					
	- Hyperlink	Yes	Undetermined***	Yes	No	Yes
	- Embed HTML link	Yes	No	Yes	No	Yes
	- JPG	No	No	No	No	No
	- PNG	No	No	Yes	No	Yes
	- Web app	No	No	Yes	No	No
	- Print option	Yes	No	Yes	No	Yes
	Default base map options	3	8	10	1	6
	Symbology options	No	Yes	Yes	No	Yes
	Label options	No	No	No	No	Yes
	Widget options	Yes	Yes*	Yes	Yes	Yes
Associated Costs	Cost/Upgraded options	$	$	$$$	Free	$
	Software download required	No	No	No	Yes	No

* Only in the paid version.
** The SMSSync app is only available on the Android Market. Web surveys can be accessed on Android and iOS devices.
*** Paid access was required to investigate this option.

supports the removal of single data entries, mass deletions, sorting and filtering, and the editing of single entries. Ushahidi, Open Data Kit and GIS Cloud have no mass delete option, and Open Data Kit is the only platform that does not allow submissions to be edited. The data export options are limited. The largest number of supported formats is five, available in Survey123 and GIS Cloud.

3.3 Data Analysis

Data analysis options are available in Maptionnaire, Survey123 and GIS Cloud, but are essentially all paid-for services. Maptionnaire does not allow access to the survey data without a payment plan, Survey123 is only accessible with an ESRI organizational account, and the premium trial of GIS Cloud's Map Editor expires after 31 days. Therefore, if the author wishes to perform any significant analysis on their data they will likely have to pay. Ushahidi and Open Data Kit do not offer geoprocessing tools.

3.4 Data Visualization

Survey123 offers the most data visualization options, while Maptionnaire has no options without payment. Open Data Kit offers lists, graphs and a map view (however the map view is watermarked). Survey 123 (ArcGIS online) and GIS Cloud have the most symbology options; the author can make new feature layers, which allows each feature to be represented by its own symbol. The option to customize symbols is available in Maptionnaire, Survey123 and GIS Cloud. GIS Cloud offers labeling options as well.

3.5 Associated Costs

Ushahidi, Maptionnaire and GIS Cloud require payment for full access to all their features, although Ushahidi is free for some endeavors upon discretion of the platform. Survey123 is not free and requires an ESRI organizational account with publisher capabilities, restricting its accessibility to citizen science projects.

Open Data Kit is advantageous for low or no budget projects since it has no incurred costs or upgraded versions requiring a payment plan. However, Open Data Kit is the only platform that requires a software download. This may restrict its use if an author does not have admin privileges on the computer they start their project on.

4. Discussion and Conclusion

We evaluated and compared five map-based crowdsourcing platforms based on their ability to facilitate geographic citizen science endeavors. It is difficult to highlight a single platform as the best option, since citizen science projects are not equally funded and are operated by people of varying technological expertise. Most platforms do have incurred costs of operation, with Survey123 being the most functional but also expensive option. Ushahidi, Maptionnaire, GIS Cloud and Open Data Kit offer alternatives to investing time and capital into developing an in-house platform. In particular, the Open Data Kit open-source software provides a free-of-charge option for projects, however its usage is not as intuitive and user-friendly as the commercial and paid alternatives. While these platforms do not offer much public engagement beyond the crowdsourcing of data, they are viable options for the collection, management, and visualization of citizen generated data.

Citizen science is helping to break barriers between scientific processes and the public; to make science and scientific enquiry openly available. The tools of citizen science, specifically web-based participatory mapping platforms, are enabling the public to become more involved, not just in the collection of scientific data, but in the planning and execution of data collection. The platforms, discussed here and the others like them, are excellent options for those lacking the capital and technical knowledge to build a data collection, management and visualization platform from the ground up. These crowdsourcing platforms make citizen science project

planning more accessible to the masses by eliminating the advanced technical skills required to develop a map-based collection program. These crowdsourcing platforms facilitate the front-end and back-end of data collection allowing individuals to focus on their data and analyze and share their results.

Overall, these platforms make citizen science more accessible to non-professionals by eliminating the need for the advanced technical skills and capital necessary to develop a map-based crowdsourcing platform. We anticipate a growing market for these platforms as niche "amateur" citizen science projects grow.

References

Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V., & Shirk, J. (2009). Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy. *BioScience*, 59(11), 977-984.

Bonter, D.N., & Cooper, C.B. (2012). Data validation in citizen science: a case study from Project FeederWatch. *Frontiers in Ecology and the Environment*, 10(6), 305-307.

Cooper, C.B., Hochachka, W.M., & Dhondt, A.A. (2011). The opportunities and challenges of citizen science as a tool for ecological research. In Dickinson, J.L., Bonney, R., (Eds.), *Citizen science: public collaboration in environmental research* (pp. 99-113). New York, New York: Cornell University Press.

Corbett, J.M., & Cochrane, L. (2017). Engaging with the Participatory Geoweb: Experiential Learning from Practice. In Campelo, C.E.C., Bertolotto, M., Corcoran, P. (Eds.) *Volunteered Geographic Information and the Future of Geospatial Data*, (pp. 1-18). IGI Global.

Eitzel, M.V., Cappadonna, J.L., Santos-Lang, C., Duerr, R.E., West, S.E., Kyba, C.C.M., ... Jiang, Q. (2017). Citizen science terminology matters: Exploring key terms. *Citizen Science: Theory and Practice*. 2(1), 1, 1-20.

Fast, V., & Hossain, F. (Under Review). An Alternative to Desktop GIS? Evaluating the Cartographic Capability of WebGIS Platforms.

Goodchild, M.F. (2007). Citizens as sensors: the world of volunteered geography. *Geojournal*, 69(4), 211-221.

Haklay, M. (2013). Citizen science and volunteered geographic information: overview and typology of participation. In: Sui, D.Z., Elwood, S., & Goodchild, M.F. (Eds.) *Crowdsourcing geographic knowledge: volunteered geographic information (VGI) in theory and practice*, (pp. 105-122). Dordrecht: Springer.

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (2018). Innovation in open science, society and policy – setting the agenda for citizen science. In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds.) *Citizen Science: Innovation in Open Science, Society and Policy*, (pp. 1-23). London: UCL Press.

Leszczynski, A., & Wilson, M.W. (2013). Guest editorial: theorizing the geoweb. *GeoJournal*, 78, 915–919. doi: 10.1007/s10708-013-9489-7

Rinner, C., Kumari, J., & Mavedati, S. (2011) A geospatial web application to map observations and opinions in environmental planning. In Li, S., Dragicevic, S., & Veenendall, B. (Eds.) *Advances in Web-based GIS, Mapping Services and Applications*, (pp. 277-291), London, England: Taylor and Francis.

Roick, O., Haklay, M., & Ellul, C. (2016). GeoKey - open infrastructure for community mapping and science. *Hum Comput*, 3, 143–159. doi: 10.15346/hc.v3i1.8

Sani, A.P., & Rinner, C. (2011). A Scalable Geoweb Tool for Argumentation Mapping. *Geomatica*, 65, 145–156.

Silvertown, J. (2009). A new dawn for citizen science. *Trends in ecology & evolution*, 24(9), 467-471. doi: https://doi.org/10.1016/j.tree.2009.03.017