Crowdsourcing: A Geographic Approach to Public Engagement

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Abstract

In this paper we examine three geographic crowdsourcing models, namely: volunteered geographic information (VGI), citizen science (CS) and participatory mapping (PM) (Goodchild, 2007; Audubon Society, 1900; and Peluso, 1995). We argue that these geographic knowledge producing practices can be adopted by governments to keep databases up to date (Budhathoki et al., 2008), to gain insight about natural resources (Conrad and Hilchey, 2011), to better understand the socio-economy of the people it governs (Johnston and Sieber, 2013) and as a form of data-based public engagement. The paper will be useful to governments and public agencies considering using geographic crowdsourcing in the future. We begin by defining VGI, CS, PM and crowdsourcing. Two typologies are then offered as methods to conceptualize these practices and the Kitchin (2014) data assemblage framework is proposed as a method by which state actors can critically examine their data infrastructures. A selection of exemplary VGI, CS and PM from Canada and the Republic of Ireland are discussed and the paper concludes with some high level recommendations for administrations considering a geographic approach to crowdsourcing.

Keywords

Volunteered Geographic Information, VGI, Citizen Science, Participatory Mapping, Crowdsourcing, Open Data, Public Engagement, Government Administration

1. Introduction

In this paper we examine three geographic crowdsourcing models, namely: volunteered geographic information (VGI), citizen science (CS) and participatory mapping (PM) (Goodchild, 2007; Audubon Society, 1900; and Peluso, 1995). We argue that these geographic knowledge producing practices can be adopted by governments to keep databases up to date (Budhathoki et al., 2008), to gain insight about natural resources (Conrad and Hilchey, 2011), to better understand the socio-economy of the people it governs (Johnston and Sieber, 2013) and as a form of data-based public engagement. The paper will be useful to governments and public agencies.

There has been a reluctance on the part of contemporary governments to ingest, use and disseminate crowdsourced generated data for a number of valid reasons, such as data accuracy, reliability, and authenticity; technological and human resource limitations; and because they have not been acquired from 'authoritative' sources (Haklay et al., 2014; Johnston and Sieber 2013; Bonney et al., 2009). Alternatively, since some maps can be out of date, and often were created in an era of less accurate measuring instruments, VGI data may in fact be of higher quality (Goodchild, 2007; Goodchild and Li, 2012). In the end the question is often about who has the authority to produce facts? Google Maps has become the defacto fact maker in mapping, even though the accuracy of its imagery for rural and remote areas is uncertain and there are no metadata to attest to the quality of the images (Goodchild, 2007; De Leeuw et al., 2009). This applies to other types of knowledge. A special report in *Nature* compared entries in the *Encyclopaedia Britannica* and *Wikipedia* and found that both contained errors (Giles, 2005). While in copyright law, there are different kinds of facts and court cases generally focus on original facts which are those "that owe their existence to the exercise of individual intellectual effort" (Scassa, 2006:3) and qualified by facts 1) discovered through skill and judgment; 2) that are valuable due to the particular selection; and 3) that are not necessarily true (Scassa, 2006).

A related question is who is given the task of producing scientific knowledge (Poovey, 1998, Latour,1987 and Hacking, 1982)? Historically, indigenous people relied on local land use, occupancy and wayfinding intelligence to survive in often hostile environments such as the Arctic (Freeman, 1976). This local and traditional knowledge was often transmitted across generations, orally and sometimes ritually in songs and stories, and illustrated in paintings or by annotating physical space with landmarks (Oguamanam, 2011). This was normally carried out by trusted authorities such as elders and new world explorers (i.e., amateur scientists, survey engineers and cartographers) relied on this knowledge to survive in unfamiliar terrain. They also transcribed local traditional knowledge along with their own observations in field notes (Pyne and Taylor, 2012) and annotated sketch maps (e.g., ISIUOP Atlas) to inform western colonial policies and practices, such as settlement, resource extraction and the demarcation of boundaries described in land treaties (Pyne, 2014). More recently, data and map archives are being interrogated revealing the contributions aboriginal people have made to science (Lauriault and Taylor 2014; Pyne 2014). Today, censuses, national mapping and the collection of administrative data are established, authoritative, scientific, objective, trusted and normalized infrastructural state knowledge producing activities (Dodge and Kitchin, 2013).

Concurrently, with the advent of open government (Martin, 2014), the public sector is no longer considered to be the sole arbiter and producer of state knowledge and it no longer maintains an institutional monopoly over the technologies of science and data infrastructures. This has been brought about by the socio-technological advances of the Internet, cell and satellite infrastructures, computerization, greater access to mobile technologies and services, the rise of statistical and cartographic knowledge (Franklin et al., 2013; Porter, 1986 and Harley, 2001), and data science (Kitchin 2014). These socio-technological advances are combined with education and the means to measure and count things coupled with the desire for evidence-based decision making. As well as a re-distribution of statistical power from the centre (Dupaquier, 1985 and Desrosières, 1998).

Specifically, a critical, engaged and technologically mediated form of geography has emerged (Connors et al., 2012; Taylor, 2002; Taylor and Lauriault 2014). Neogeography (Connors et al., 2012; Coleman et al., 2009) has transformed members of the public, albeit often a highly qualified public with specialized, scientific and technological skills. from passive consumers of authoritative data into data producers (Goodchild, 2007 and Dodge and Kitchin, 2013) or prosumers (i.e., producers who are also consumers)(Ritzer, 2008 and Budhathoki et al., 2008). Further, the advent of open access science, open source software development, open data, social media, transparency and open government movements, have made public sector data more accessible. There is now a general acceptance on the part of government administrators that data are state assets to be shared with citizens, civil society organizations and the private sector (e.g., G8 Open Data Charter**,** Open Government Partnership). Despite this even the most 'open' of governments (e.g., see OGP plans for Canada and the UK) have not fully embraced data-informed deliberative democracy when it comes to planning, nor have they effectively structured public engagement beyond soliciting input in online forms. However they have been more receptive to services being mediated by "apps" as seen by the proliferation of Hackathon events.

Some governments have been sharing their geospatial data in spatial data infrastructures for quite some time (e.g., Geogratis) and administrative datasets are beginning to be managed in such a way that they can be shared more freely in open data portals (ex.data.gov.ie, data.gov.ca). Yet, there remains reluctance on the part of government to ingest, use and re-disseminate the data produced by 'non-authoritative' sources. This reluctance persists, even though many excellent resources and primers have been produced by and for government about the opportunities and challenges presented by crowdsourced data driven models of public engagement (Haklay et al., 2014, GeoConnections, 2012 and Socientize.eu).

The authors of this paper are proponents of VGI, CS and PM as forms of crowdsourcing, but do not have an uncritical view of these practices. Elsewhere they are actively engaged in: reflexively building CS Apps (e.g., EPA Ireland Drinking Water Assessment); producing atlases that include VGI generated maps and examine frameworks which ingest and vet crowdsourced data (Taylor and Lauriault, 2014) and participate in international VGI research networks (e.g., EU COST Actions "Mapping and the Citizen Sensor" and "ENERGIC"). In addition they have been contributing to a new form of scholarship called critical data studies (Kitchin and Lauriault 2014). As current and former public servants, government data policy advisors and as scientists, they understand the reluctance on the part of government to embrace crowdsourcing as an official practice. They propose VGI, CS and PM as established geographic crowdsourcing models and if critically considered and carefully rolled-out these can provide reliable and valid data and a deep level of public engagement. While being cognizant of the perils of libertarian ideologies, neo-liberal and technocratic forms of management and the dangers of direct democracy, the authors believe that evidence-informed decision making in public policy is better than guesswork, cronyism and patronage (Kitchin, Lauriault and McArdle, 2014). The active engagement of citizens in the production of fact-based knowledge can be a form of deliberative democracy and a way for the open government arms of government to engage with the public.

The remainder of the paper is structured as follows. We open by defining VGI, CS, PM and crowdsourcing. Two typologies are then offered as methods to conceptualize these practices and the Kitchin (2014) data assemblage framework is proposed as a method by which state actors can critically examine their data infrastructures. A selection of exemplary VGI, CS and PM from Canada and the Republic of Ireland are discussed and the paper concludes with some high level recommendations for administrations considering geographic crowdsourcing.

2. Definitions

There are number of affordances identified for government to use data collected through VGI (Budhathoki et al., 2008), CS (Bonney et al., 2009), and PM (Bryan, 2014 and Brown and Kyttä, 2014). This includes the potential for the public to act as "sensors of their environment" (Goodchild, 2007;Sieber and Johnson, 2013) and to compare and analyze crowdsourced data with government data (de Leeuw et al., 2011). In the case of local and traditional knowledge it is an opportunity for other worldviews to be represented such as indigenous toponyms, land use and occupancy, or biodiversity (Stafford et al., 2010; Taylor and Lauriault, 2014). In an era of austerity and limited human resources CS, VGI and PM offer an opportunity to include the public in data collection and analysis. We suggest that governments can build public engagement opportunities by capitalizing on these three established geographic crowdsourcing models. Furthermore these models may also inform crowdsourcing processes more broadly.

2.1. Volunteered Geographic Information

Volunteered geographic information (VGI) is a valid mechanism for the acquisition and compilation of geographic information. As such it offers substantial advantages. VGI is a:

> *version of crowd-sourcing in which members of the general public create and contribute georeferenced facts about the Earth's surface and near-surface to websites where the facts are synthesized into databases. This phenomenon is part of a broader trend, but has special characteristics that are attributable to the geographic nature of the information, in other words to the requirement that every contributed fact specifies both a geographic location and a description of one or more properties present at that location* (Goodchild 2012).

VGI is now common. Map coordinates have become a form of social media and the map is considered as a unifying framework for online sharing by experts such as cartographers and geomaticians and non-experts such as neogeographers (Turner, 2006 and Engler, Scassa and Taylor,2014). The GeoWeb or geospatial web 2.0 has been an enabler of VGI with the release of GoogleMaps, MS Virtual Earth and Yahoo Maps in 2005 (Scharl and Tochtermann, 2007). There has been a remarkable increase in the number of GIS scholars actively engaged in VGI (Mooney et. al, 2013). Research clusters (EU COST Actions such as "Mapping and the Citizen Sensor" and "European Network Exploring Research into Geospatial Information Crowdsourcing") have and Open Street Map is the largest and best known VGI project with over 1.8 million registered contributors and an average of about 3,000 contributors working actively on a daily basis (OSM Stats, 2014).

Some popular geospatial data related projects beyond OSM are: *Fix My Street* which enables volunteers to report the location of potholes to their respective municipal officials, *GeoNames* which is a volunteered gazetteer that includes over 10 000 000 geographical names, and *GeoCoder.ca* a tool that enables volunteers to add geographic coordinates to postal codes, their residences and street intersections. The private sector in car navigation systems have been allowing their customer to update their databases and to point out errors for quite some time.

Quick View Summary:

Advantages: VGI has been shown to be capable of leveraging collaboration amongst millions of citizen contributors globally through passive (extraction of VGI from social media) and active (contribution to VGI projects) approaches. VGI offers governments the opportunity to collaborate on the collection of geographic data and information with millions of 'citizen sensors'.

Disadvantages: Numerous studies have shown that VGI is very often concentrated on urban areas with less focus on rural, socially deprived, and geographically difficult terrain. Concerns are also documented regarding the quality of the data generated by citizens who are not necessarily skilled at collection of geographic data and information.

2.2. Citizen Science

Citizen science involves the public in researcher. It is "a process where concerned citizens, government agencies, industry, academia, community groups, and local institutions collaborate to monitor, track and respond to issues of common community [environmental] concern" (Conrad and Hilchey, 2011). It is also "a research technique which enlists the public in gathering scientific data and information. Large-scale citizen science projects can engage participants in continental or even global data-gathering networks" (Bonney et al., 2009). It is a form of community engagement and is a way to manage and monitor natural resources. The focus of recent citizen science is not the traditional "scientists using citizens as data collectors" or sensors but rather, "citizens as scientists".

There are many citizen science projects and the following are renowned: *Marine Litter Watch* where litter is quantified, *Safecast* which provides citizens with the tools and techniques to monitor radiation levels in their communities and to safely contribute those data into maps, and *Project Noah* a tool to explore and document wildlife.

Quick View Summary:

Advantages: CS enlists the public in collecting large quantities of environmental data across a variety of habitats and locations over potentially long periods of time. Contributions from citizen scientists have been very successful in advancing scientific knowledge in areas such as ornithology, environmental habitat monitoring and species tracking.

Disadvantages: As with VGI, academics, government and industry have expressed concern over the quality and accuracy of data and information collected and generated by CS. Sustainability of CS projects is also an issue where citizens lose interest in a CS for a variety of reasons which has a cascading effect on the overall quality and accuracy of the generated data.

2.3. Participatory Mapping

Participatory mapping,

> *is a general term used to define a set of approaches and techniques that combines the tools of modern cartography with participatory methods to represent the spatial knowledge of local communities. It is based on the premise that local inhabitants possess expert knowledge of their local environments which can be expressed in a geographical framework which is easily understandable and universally recognised. Participatory maps often represent a socially or culturally distinct understanding of landscape and include information that is excluded from mainstream or official maps. Maps created by local communities represent the place in which they live, showing those elements that communities themselves perceive as important such as customary land boundaries, traditional natural resource management practices, sacred areas, and so on (Mapping for Rights, 2014).*

This definition refers to the mapping of local and traditional knowledge often carried out by aboriginal communities (Taylor and Lauriault, 2014). Related practices are community based mapping, participatory GIS more familiarly known a (PPGIS) (Elwood, 2006) and counter mapping (Peluso, 1995). Participatory mapping is often a component of overseas development projects and community based research, and can involve the use of three dimensional paper maché topographic maps, sketched maps on Mylar sheets, desktop GIS, geoweb technologies or a combination of all of the above. The Sea Ice Use and Occupancy Project (SIUOP) is a popular participatory mapping project based in Canada's north which has been incorporated into school curricula in Nunavut (Taylor, Cowan, Ljubicic and Sullivan, 2014).

Quick View Summary:

Advantages: Participatory mapping can enhance the quality of local governance by creating processes that are more democratic and equitable. By doing so it can increase the transparency of governmental decision making. Participatory mapping provides a valuable visible representation of what a community of citizens perceives as its place and the significant features within their local areas. Consequently it provides a means of accessing local and community-based knowledge for use in decision making.

Disadvantages: Participatory mapping can be very time-consuming and costly depending on the scale of the participatory mapping processes. Time is needed to build meaningful relationships between intermediaries and communities. Complex decision making and policy-impact assessment can be difficult to integrate into participatory mapping as the overall process can become complex and cause local communities and citizens to lose interest.

2.4. Crowdsourcing

VGI, CS and PM are all forms of crowdsourcing and are also forms of user-generated content, user-created content or consumer-generated media. Social media platforms such as FourSquare, Waze or Flickr blur the lines between all three. Crowdsourcing however is more familiarly understood as being a type of participative online work activity:

> *in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage what the user has brought to the venture, whose form will depend on the type of activity undertaken* (Estellés-Arolas and González-Ladrón-de-Guevara, 2012:197).

Some of the most renowned crowdsourcing projects are *GalaxyZoo* where people identify types of galaxies based on set of images, *Mechanical Turk* which is a job creation platform that mobilizes both volunteers and remunerated distributed part time contractors to carry out tasks which machines alone cannot. Some include *Google Flu Trends* in this category, but it is more analogous to a big data project that monitors a number of Google searches related to flu outbreaks.

Quick View Summary:

Advantages: As stated above Crowdsourcing is an umbrella term for VGI, CS, PM and many other forms of user-generated content on the Internet. Whilst our paper focuses on voluntary crowdsourcing, infrastructures such as Mechanical Turk allow companies and organisations to 'buy' crowdsourced labour to complete tasks. This can lead to very significant overall costs and resource savings to those organisations. As social media becomes ever more pervasive so too do the opportunities for crowdsourcing.

Disadvantages: Despite the low costs (or in some cases zero costs) of crowdsourcing in general there are often problems with the quality of the work carried out by members of the crowd. Without rigorous control over the crowdsourcing activity being carried out organisations may have to deal with vast quantities of data and information which may require significant resources to extract knowledge and added-value from. A number of unfavourable labour practices have emerged from projects such as Mechanical Turk that which we are only beginning to understand (.

3. Analytical Resources

In this section we examine resources of utility to government officials who are considering undertaking VGI, CS and and PM either as a project or as a policy strategy for public engagement. We briefly describe two typologies and a framework which can guide decision making and we point to useful reports prepared specifically for government on the topic.

3.1 Typologies

VGI, CS, PM and crowdsourcing have reached a point in practice where there is warrant for them to be classified into typologies. Here we provide two which classify these activities according to the type of contributor and their contributions (Coleman, Georgiadou and Labonte, 2009) and the level of participation and engagement (Haklay, 2013).

3.1.1. Type of Contributor

David Coleman, Yola Georgiadou and Jeff Labonte (2009) have been at the forefront of scholarship about spatial data infrastructures and building them. Their typology is based on the literature related to VGI and PM as well as grounded experience. Their objective was to develop a VGI assessment tool for public administrators. They first categorize contributors into five classes as follows and as illustrated in figure 1. These are ranked by level of knowledge, whether or not there is remuneration, legal liability or reputational risk.

(1) **Neophyte:** an individual without a formal background in a subject, but who possesses the interest, time, and willingness to offer an opinion;

(2) **Interested Amateur:** someone discovered an interest in a subject, has begun reading the background literature, consulted with other colleagues and experts about specific issues, is experimenting with its application, and who is gaining experience in appreciating the subject;

(3) **Expert Amateur:** a person who may know a lot about a subject, practices it passionately on occasion, but still does not rely on it for a living;

(4) **Expert Professional:** someone who has studied and practices a subject, relies on that knowledge for a living, and may be sued if their products, opinions and/or recommendations are proven inadequate, incorrect or libellous; and

(5) **Expert Authority:** a person who has widely studied and long practiced a subject to the point where he or she is recognized to possess an established record of providing high-quality products and services and/or well-informed opinions, and stands to lose that reputation and perhaps their livelihood if that credibility is lost even temporarily.

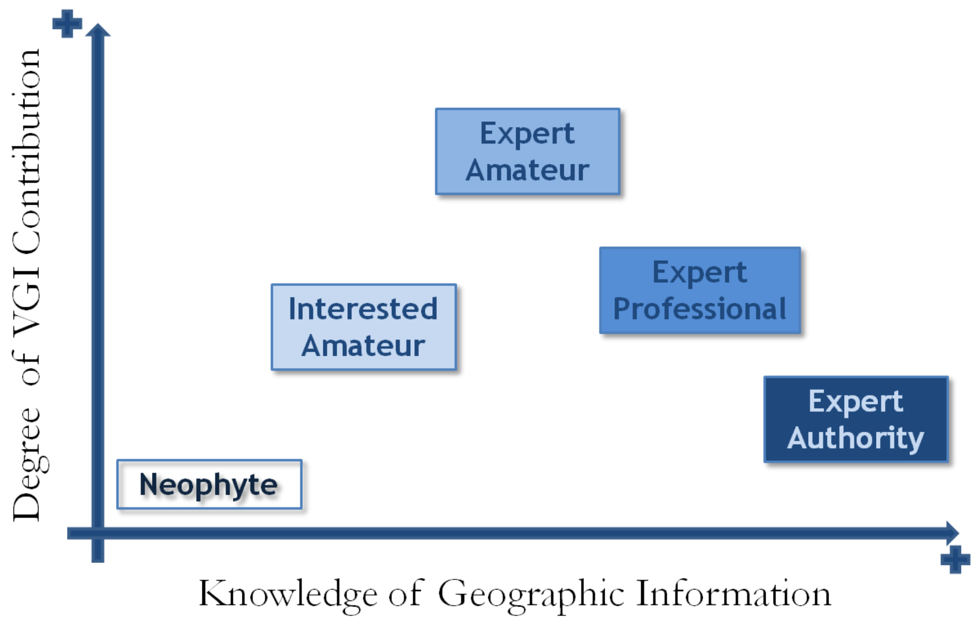

Figure 1. Volunteered Geographic Information: the Nature and Motivation of Producers (Coleman, Georgiadou and Labonte, 2009).

Coleman et al. agree that these classes of VGI contributors are not mutually exclusive. For example it is possible that a person knows little about a subject but may be a GIS expert who is fully knowledgeable of GPS, coordinate systems and mapping. They also examine the types of VGI projects volunteers contribute to such as mapping and navigation (e.g., NAVTEQ updates), social networks (e.g., OSM), civic and government project (e.g. PPGIS), and emergency reporting, and then describe the kinds of data contribution activities these 5 types of contributors might make. Furthermore, they distinguish contributors, by other characteristics such as their humanity (i.e., human or automated robot contributor), the frequency of their contributions, the quality and veracity of data operations, and reputational reliability.

In addition, they examined the literature on the motivation of contributors in the free and open source community (FOSS) as well as Wikipedia and have identified the following characteristics: altruism, professional or personal interest, intellectual stimulation, protection or enhancement of a personal investment, social reward, enhanced personal reputation, provides an outlet for creative and independent self-expression; and finally pride of place. Some negative motivations were also identified which could preclude the automation of contributions into a system and these are: mischief, an agenda that can bias contributions, and malice and/or criminal intent. The authors also provide a list of considerations institutional actors should take into account should they decide to embark on VGI types of projects.

The GeoConnections program responsible for the delivery of the Canadian Geospatial Data Infrastructure, solicited government consultancy Hickling Arthur and Low (HAL) (2012) to develop a VGI Primer for the Government of Canada. This primer builds upon the work of Coleman et al. as seen in figure 2. In this case projects are arranged along a spectrum of authorized contributors often expert professional or authorities to open systems that will accept content from anyone. In addition, the projects are considered in terms of the formality of data quality control methods which range from iterative refinements made by individual citizen contributors to quality assessments made by trained geographic professionals.

Figure 2. VGI Quality Control and System Openness (GeoConnections, 2012)

3.1.2. Level of Participation

Haklay (2013) has developed a typology from both the theory and practice of VGI and CS. His typology discussed below, is grounded in his experience in CS projects, his reflections on the production of knowledge and the literature about VGI, CS, PM and crowdsourcing. As seen in figure 3 below, the topology considers formal scientific knowledge, engagement and cognitive input:

> ***Level 1 Crowdsourcing:*** participation is limited to the provision of resources, and cognitive engagement is minimal. In participatory sensing, or citizens as sensors approaches, participants are asked to carry sensors around, collect data and report feed these back to the

experiment organiser. From a scientific perspective the characteristics of the instrumentation are known (e.g. the accuracy of a GPS receiver) and the experiment is controlled to some extent as assumptions about the quality of the information are made.

Level 2 Distributed intelligence: here the cognitive ability of the participants is considered a resource. Participants are offered some basic training and collect data or carry out one or more simple interpretation types of activities. Quality assessments are made by project designers and attention is given to volunteer contributors to support ongoing learning.

Level 3 Community science: in this case participants help develop the problem to be investigated and in consultation with scientists and experts data collection methods are devised. Experts provide analytical expertise and interpret the results. Volunteers may become experts the data collection and analysis through their engagement and may suggest new research questions that can be explored with the data they have collected.

Level 4 Collaborative science or extreme citizen science: this is an integrated activity where professional and non-professional scientists decide which scientific problems to work on. Collaborative decisions are also made on the nature of the data to be collected to ensure these are valid and adhere to scientific protocols while also matching the motivations and interests of participants. The participants may also be involved in the analysis and publication or utilisation of results. Scientists act as facilitators as well as experts.

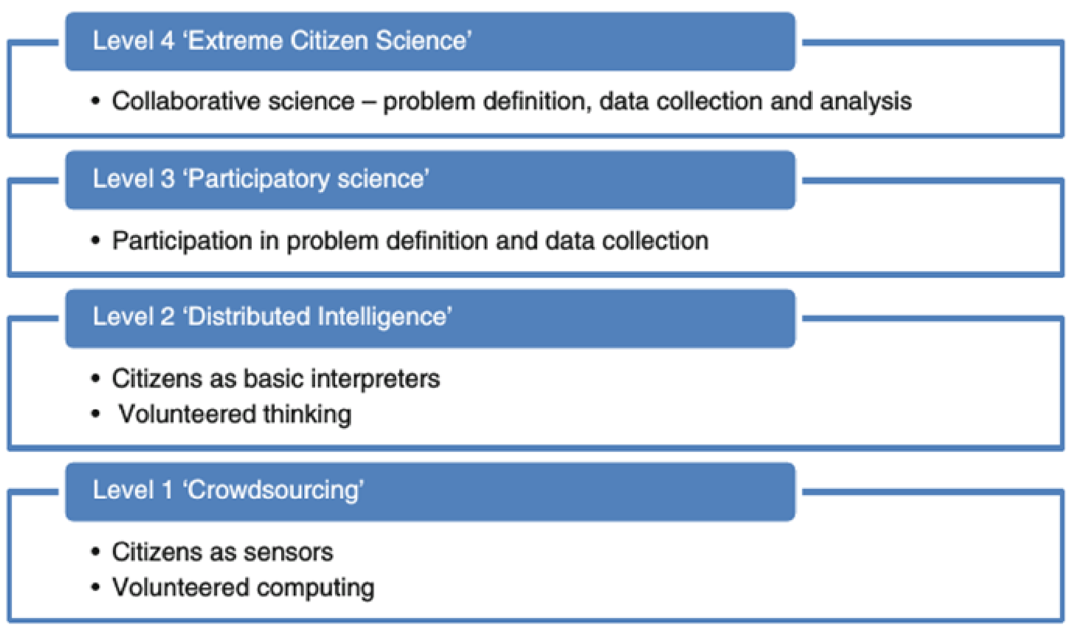

Figure 3. Levels of Participation and Engagement in Citizen Science Projects (Haklay, 2013)

In Haklay's typology participants can move from one level to the next as they gain experience and learn by doing. His approach critically reflects upon the knowledge production process and questions the professionalization of science where the tools of the instruments of science were once restricted to those with the required credentials to use them. In addition, Haklay suggests that the separation between scientist and public needs to be reconsidered while professional scientist need to adjust to this new role of scientist as mediator of knowledge and not as the sole authority of scientific truth. More importantly, citizen science, especially, extreme citizen science, may allow scientists to re-envisage their role as citizens and as scientists. "This might end up being the most important outcome of citizen science as a whole as it might eventually catalyse the education of scientists to engage more fully with society" (Haklay, 2013:14).

3.1.3. Data Assemblage Framework

As big data, open data and data infrastructures (Kitchin, 2014) have become part of scientific discourse there is a growing recognition that a framework to critically examine data, code and infrastructure is required. Rob Kitchin (2014) developed a critical data studies (Kitchin and Lauriault, 2014) approach to the examination of data, recognizing that data are not simply discrete facts, but form an assemblage as described in Table 1. Kitchin's data assemblage is conceived as a complex socio-technical system consisting of a number of inter-related elements. This framework has utility in understanding and contextualizing the wider changing data landscape. It also illuminates where the practice and outcomes of VGI, CS, PM and crowdsourcing are situated. The two typologies discussed above include many of its constituent elements such as: — systems of thought; forms of knowledge; finance; political economy; governmentalities; materialities and infrastructures; practices; organisations and institutions; subjectivities and communities; places; and marketplaces. These elements work together to frame how data are produced, managed, analyzed, shared and used, and also provide a way for administrators to consider potential public engagement projects in a broader context.

Table 1. Kitchin's Data Assemblage Framework (Kitchin, 2014)

Attributes	Elements
Systems of thought	Modes of thinking, philosophies, theories, models, ideologies, rationalities, etc.
Forms of knowledge	Research texts, manuals, magazines, websites, experience, word of mouth, chat forums, etc.
Finance	Business models, investment, venture capital, grants, philanthropy, profit, etc.
Political economy	Policy, tax regimes, public and political opinion, ethical considerations, etc.
Govern-mentalities / Legalities	Data standards, file formats, system requirements, protocols, regulations, laws, licensing, intellectual property regimes, etc.
Materialities and infrastructures	Paper/pens, computers, digital devices, sensors, scanners, databases, networks, servers, etc.
Practices	Techniques, ways of doing, learned behaviours, scientific conventions, etc.
Organisations and institutions	Archives, corporations, consultants, manufacturers, retailers, government agencies, universities, conferences, clubs and societies, committees and boards, communities of practice, etc.
Subjectivities and communities	Of data producers, curators, managers, analysts, scientists, politicians, users, citizens, etc.
Places	Labs, offices, field sites, data centres, server farms, business parks, etc, and their agglomerations
Marketplace	For data, its derivatives (e.g., text, tables, graphs, maps), analysts, analytic software, interpretations, etc.

3.2. Resources

The World Bank sponsored *Crowdsourced Geographic Information Use in Government* (Haklay et al., 2014) which examines 29 government VGI, CS, and PM projects, in 20 countries, in Asia, Africa, Europe and North America. Projects range from natural disaster response, roadkill mapping, slum management, wildlife tracking, and citizen engagement to name a few. The authors conducted a deep analysis of seven case studies, which helped them construct a useful analytical framework that consisted of collecting the following attributes across all 29 projects: interaction type, trigger event, domain, organization, actors, data sets, process, feedback, goal, side effects, contact point, policy, legal, standards, data quality, technology, sustainability, credibility of the source, reservations and security. Projects were then grouped and analyzed according to these attributes. These are not dissimilar to the elements in Kitchin's data assemblage. The authors make clear that there is no magical formula for success but do provide a series of lessons learned. These include: ensuring that: contributors know how their data have been used to inform policy, VGI should be integrated within existing GIS systems and are not a replacement, biases in terms of coverage and time are recognized, there is a need for business and sustainability plans, and that dealing with intellectual property is important and is knowledge and respect for reporting channels.

The *White Paper on Citizen Science (2014)* in Europe produced by the Socientize Consortium and sponsored by the European Union is the result of a two year study of CS activities, institutions, initiatives and funding programs in Europe. The objective is to promote this type of ICT-enabled citizen, scientist and government form of engagement. It is a wonderfully illustrated White Paper which defines CS, provides a matrix of its characteristics along the lines of values and attributes, provides examples of form and impacts. It provides a series of pan European macro policy level recommendations, meso recommendations of community frameworks and different citizen science mediators and micro hands-on recommendations are outlined. Most of the recommendations are geared toward academic and public sector scientists and address concerns from data management, infrastructure (technological and intellectual) and cultural change.

The *GeoConnections VGI Primer* (2012) is a response to the growing demand for the federal government of Canada to consider this form of public engagement. The VGI Primer is part of a series of Canadian Geospatial Data Infrastructure Operational Policy Documents which cover topics such as intellectual property, open source, open licences, preservation and archiving of data to name a few. The VGI Primer is short and describes the practice including the type of contributor typologies just discussed. This Primer is in alignment with policy directions being pursued by Natural Resources Canada toward the National Geographic Platform which integrates open data with SDI.

As part of the re-envisioning process regarding national mapping and the direction of the Geospatial Data Infrastructure in Canada a multi-stakeholder forum for open dialogue and collaboration on issues, challenges and opportunities was established between 2012-2013. This was entitled the *Canadian Geomatics Community Round Table*. It includes representatives of organizations spanning the sector, including: federal, provincial and territorial governments, private sector companies, academic institutions, non-governmental organizations, professional associations, and users of geospatial information and services. The objective was the formulation of a new *Pan-Canadian Geomatics Strategy*. The final version of the Strategy (2014) reflects discussions and consensus and understandably, the focus is not exclusively about VGI, but it is an official part of the strategy and a legitimate data source.

3.3. Summary

These two typologies and the framework reveal the tensions and the opportunities presented by VGI, CS, PM and crowdsourcing, most notably between what is knowledge, a knowledge contribution, knowledge production, the democratisation of the tools of science as well as their data assemblage. The authors of these typologies recognize the constraints of public sector institutions and provide a lens through which administrators and public sector scientists can examine problems. These typologies also offer public engagement frameworks that satisfy common concerns while also allowing for critical reflection. In addition the four government resources provide public administrations with concrete examples on how these practices can be enacted in government.

The following section describes a selection of exemplary geographic VGI, PM, and CS projects from the Republic of Ireland and Canada.

4. VGI, CS and PM examples from the Republic of Ireland and Canada

Four projects from two jurisdictions are examined here as they demonstrate a balance between open and restricted systems include, a mix of contributor types from neophyte to expert authority, different levels of engagement and participation, and built with robust data infrastructures and have varying types of data quality controls.

4.1.1. National Biodiversity Data Centre of Ireland (NBDCI)

The *National Biodiversity Data Centre of Ireland (NBDCI)*, answered the call by several biodiversity organizations in Ireland, primarily academic, for a biodiversity centre. It is a community science mapping and database project. Actors recognized that to monitor biodiversity successfully it would not be feasible, for the small number of professional scientists in Ireland. The data input infrastructure was therefore designed for citizen engagement in data collection. The goals of the NBDCI were to elevate understanding of biodiversity in Ireland and widen the base from which observational data could be obtained. Data are collected by a wide range of people, such as engaged 'citizen scientists', the general public and by highly skilled university researchers in the domain. Data are submitted online via a set of species and site based forms that include provenancial information about the data submitter, as well as attributes about the data including the ability to upload an image. Mobile device based input systems are also available. The input data form is based on the Global Biodiversity Information Facility *de facto* data standard to facilitate comparability. Larger datasets can be submitted by email. Data are quickly input, verified, validated and made available for access and visualisation on an online map. There are some time constraint pressures on behalf of data validators therefore limiting feedback to contributors. The NBDCI works with other arms of government in Ireland (National Parks and Wildlife, Heritage, Department of Environment etc) to develop and implement Biodiversity policy and it is with this database that policy decisions are assisted. In terms of the type of contributor, level of participation, quality control and degree of openness as per the typologies just discussed and as seen in Figure 5 below, the *NBDCI* comprises expert professionals and expert amateurs in terms of the type of contributors, and more closely resembles the community science level of participation. It has a high to moderate level of quality control and is a relatively closed as a system.

4.1.2. Coastwatch in Ireland

Coastwatch in Ireland, is part of an international EU network of 23 countries, comprised of environmental groups, universities and other educational institutions, who in turn work with local groups and individuals along the coastlines of Europe. It was spearheaded by a group of people who believed that citizens being involved in coastal management were key to effective action in this area. The objective is to conduct a yearly coastal survey and build an up-to-date database to be used as a platform for policy change/development by government. The Coastwatch Survey is designed to give an overview of the state of the coast and involves volunteers from all walks of life who check their chosen 500m stretch of coast (survey unit) once around low tide and systematically jotting observations in a paper based questionnaire while on the shore. More enthusiastic citizen scientists can augment their survey by conducting water tests. Over 900 volunteers took part in the 2013 survey. Participants 'book a spot' on the coast from on online map, they log on and download the questionnaire, documentation, and survey guide notes, etc. Depending on their level of skills they can download additional surveys including work with EU projects on sea water transparency and colour surveying (deep water access required) and harbour waste survey (harbours, marinas, slipways, piers). Finally depending on the expertise of the citizen they can obtain nitrate testing kits, litter sample containers, etc from regional coordinators. All data are then verified by skilled experts who digitize the data. *Coastwatch in Ireland* exemplifies both a community and extreme CS level of participation that includes all types of data contributors and like the NBDCI it has a high to moderate level of quality control and is a relatively closed as a system.

4.1.3. ESRI Canada Community Map Program

The *ESRI Canada Community Map Program* responded to the need for a multi-scaled high quality standardized framework dataset of local areas and the need for an infrastructure to manage and disseminate these data. Canada is a federation with three levels of government, federal, provincial/territorial and municipality. Each has very different jurisdictional responsibilities. It is therefore not the responsibility of the national government to build a map of cities, as municipalities and counties fall within the jurisdiction of provinces and territories. In this case a private sector entity intervened to provide an infrastructure and expertise to local authorities to contribute data that can be integrated into a national map. Local areas can contribute layers such as imagery, parcels, contours, water bodies, land use, buildings, roads, administrative and city/neighbourhood boundaries, landmark areas, parks and points of interest. Data are also fact checked by contributors and cross checked with other national and international datasets. Contributors retain ownership of the data they contribute but are required to provide a royalty-free license for ESRI Canada to publish these data publicly. The *ESRI Canada Community Map Program* is a closed and controlled VGI environment, with a formal and high level of quality controls it adheres to industry standards and relies on its in house professional expert as data contributors who manage the tools to convert the data submitted by public sector authorities. The level of participation is analogous to the collaborative science model, but among expert professionals and less so by citizens, although the data like all the examples here, are available to the public.

4.1.4. Cybercartographic Atlases

Cybercartography (Taylor, 1997, 2002) is a theory and a practice which involves critically, iteratively and reflexively building atlases, atlas platform, the participatory collection of data with aboriginal communities and the production of multimedia, multisensory, multidimensional, multidisciplinary maps and databases in partnership with government and non-governmental organizations (Taylor, 2002 and Taylor and Lauriault, 2014). The Geomatics and Cartographic Research Centre is an academic centre which has in the last decade has been approached by a number of aboriginal communities in Canada's north to digitize and map their local and traditional knowledge, and to collaborate and manage these with them into atlases which become a type of community archive. Data are sometimes submitted as a database of audio visual material from a community who wish to have that content mapped (Keith, Crockatt and Hayes, 2014 and Aporta et al., 2014). Data are collected by archival researchers who solicit descriptive information about the data artifacts collected from elders (Payne, Hayes and Ellison, 2014 and Pyne, 2014) and data may be collected in the field by hunters and elders who map points of interest, features and travel or hunting routes (Lujbicic et al., 2014). Mapping is done by the GCRC but the analysis and final rendering is done in collaboration with contributing communities and individuals. Data provenance is clear, and it is understood that maps and atlases are multi-authored objects. Knowledge contributed by aboriginal communities is unstructured according to common western ontologies, therefore the atlas framework, as seen in figure 4 is structured in such a way as to allow traditional ontologies to emerge (Hayes, Pulsifer and Fiset, 2014). Atlas code is also distributed on GitHub as open source. New data use and licence agreements (Scassa, Lauriault and Taylor, 2014) have been created and a Cybercartographic VGI framework has been developed based on the elements of cybercartography, types of contributors and VGI approaches (Engler, Scassa and Taylor, 2014). *Cybercartographic Atlases,* include a different kind of contributor than those defined by Coleman et al. (2012), since aboriginal elders, hunters and other data and knowledge contributors are expert professionals accountable to their communities and expert authorities by virtue of their status in their respective Inuit and Northern Indigenous peoples traditional knowledge frameworks. In terms of level of participation, these projects would be classified as collaborative science or extreme citizen science, while data quality is moderately to highly controlled depending on its nature and the context of the maps being produced, while the system is more on the closed side, in the sense that VGI and other data contributions are verified. It is important in this case to mention, that many datasets are not public due to their sensitive nature, for example the location of polar bear dens, sacred sites, hunting grounds or other environmentally sensitive areas. Those data and maps would be available to the communities who have authority according to their respective norms. In addition, while data are managed in the south, data remain the intellectual property of the data contributors and the GCRC are considered their steward or archive.

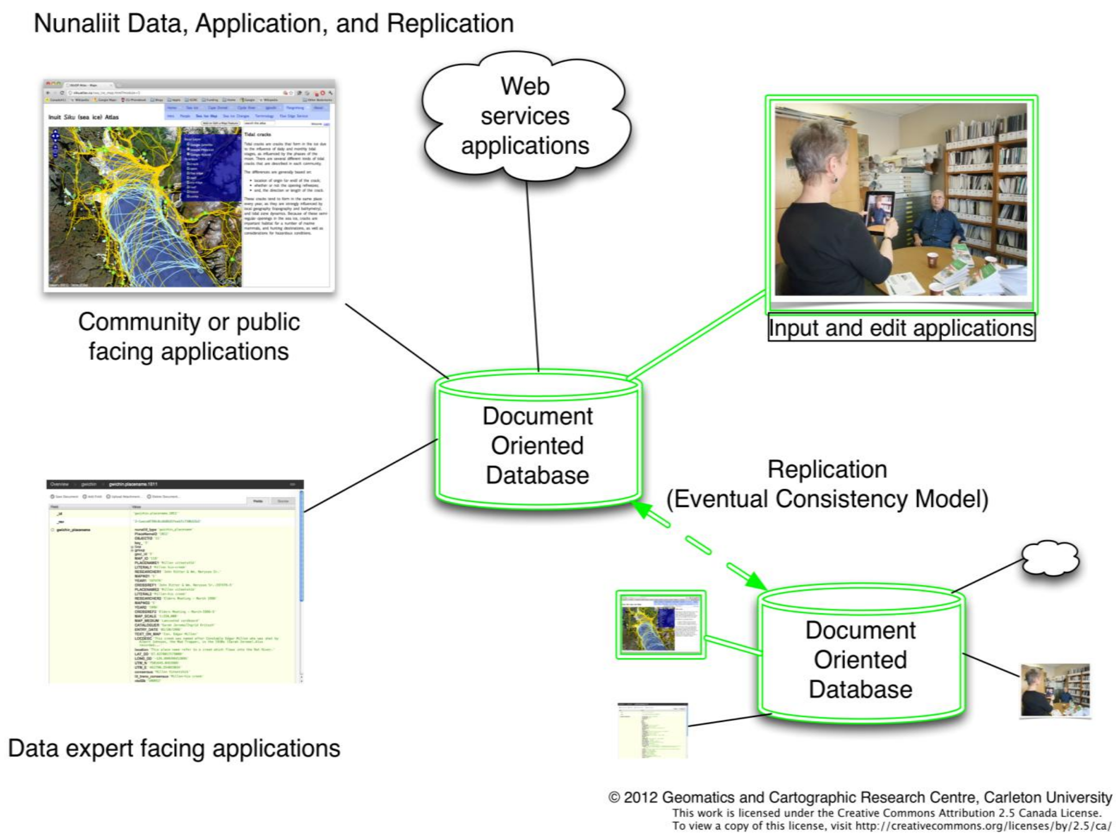

Figure 4. Cybercartographic Atlas Infrastructure Architecture

4.2. Summary

These four projects, as well as the examples listed earlier, are arranged according to the degree of data quality formality and system openness as seen in Figure 5 below. We considered these four projects (2 Irish and 2 Canadian) to be exemplary models of CS, VGI and PM, since they address a number of the data quality and contributor controls that would meet the requirements and address the concerns that most public officials would have in implementing such systems. In other words, they are crowdsourced projects that operate according to conventional understandings of how science is done. In addition, all of these have quite stable infrastructures, adhere to good data management processes and are sustainable. Finally, these models could be deployed by public sector administrations in a targeted way to engage with the public and to gather information that would otherwise be too expensive, difficult to collect. In the four cases we selected from Ireland and Canada, the data, information collected and the knowledge produced can be used to inform decisions by both government and citizens.

Finally, we did not critically discuss all these four projects as per the Kitchin data assemblage, however, an examination of the government resources provided as well as the types of characteristics we focussed on in the description of these projects can be found in the attribute and elements of that assemblage. For example, both frameworks in terms of the type of contributor and level of participation are elements of the attribute forms of knowledge, while elements of data quality, standards, norms, data ownership and intellectual property are elements of governmentality, the description of the models form part of practices. We also discussed organizations and institutions as well as subjectivities while traditional knowledge is a system of thought. The Kitchin data assemblage, is not a check list, but it does provide a framework to analyse CS, VGI and PM projects.

Figure 5. Generalized Quality Control and System Openness of Examples

5. Conclusions and Recommendations

Given all of the positives offered by crowdsourcing, as outlined in this paper, it would be foolish to simply recommend that in the face of resource constraints and public engagement requirements governments *must* begin to adopt crowdsourcing for both public engagement and enhanced data and information collection and analysis. Both government and the crowdsourcing communities of CS, VGI and PM must independently consider and evaluate how they engage, interact and benefit each other. No magic bullet exists in how governments can adopt crowdsourcing (Haklay et al., 2014; Brabham, 2013; Coleman et al. 2009 and Conrad and Hilchey, 2011). The examples described above show specific situations where crowdsourcing and government policy have collaborated successfully. While there are valuable lessons from these examples there is no guarantee that their success can be transferred and translated successfully to new government-crowdsourcing engagements. In the discussion below we outline several key recommendations applicable to both government and crowdsourcing communities on how to begin building the structures for successful future government-crowdsourcing engagement. We structure our recommendations as follows. Each recommendation includes the actor (Governments or Crowdsourcing Communities) to which the recommendation principally applies. We also provide a thematic question or principle to identify each recommendation by and we provide seven overall recommendations. These are outlined as follows:

- **Governments: What will crowdsourcing be used for exactly?** Governments must decide which type of crowdsourced data they are willing to use and equally for which tasks, analysis, reporting or monitoring they will use crowdsourced data for (Johnson and Sieber, 2013 and Coleman et al., 2009). Will crowdsourcing be used as a public engagement exercise or will it be used towards developing policy, supplementing monitoring, updating databases or generating new knowledge for the benefit of society? What are the questions which crowdsourcing geographic data can answer according to the characteristics of the relevant citizen communities (Haklay, 2013)?
- **Communities: How will the community work with government and associated agencies?** CS, VGI and PM communities and community projects must clearly establish their own rules of engagement with government agencies on crowdsourced activities. Engagement with government agencies will require allocation of additional resources (time, people, skills, etc) to build a successful working relationship. Allocation of these resources must be sustainable for a potentially long period of time. One of the barriers preventing governments adopting crowdsourcing is concerns about its long-term sustainability (Brabham, 2012).
- **Governments: How do you propose to use Crowdsourced Data?** How will the data and information collected and generated by crowdsourced activities be integrated into well established data flows within government organisations? This will require government organisations to carefully design modified data flows and QA/QC mechanisms to ingest data and information from crowdsourcing (European Commission, 2012 and Martin, 2014). In a similar vein crowdsourcing communities must decide upon which usages of their data and information they are comfortable with. Government agencies should commit upfront to the degree to which crowdsourcing will be put to use (Brabham, 2013).
- **Governments: Establish positive compromises**. New rules and legislation may need to be introduced to balance the rights of the individuals, crowdsourcing communities and government organisations involved in this shared engagement (Coleman et al., 2009 and Hunter et al., 2012). Governments must be transparent and responsive (Brabham, 2013).
- **Governments and Communities: Consider your Experimental Design**. Government organisations must invest resources into developing unambiguous and robust experimental designs if they plan to utilise crowdsourcing for data and information collection. This is acutely important in situations where data and information collection tasks or routines are different to those currently carried out by the crowdsourcing communities. Conversely if government organisations are going to directly use outputs from existing crowdsourcing projects (such as Open Street Map, GeoNames, etc) then it is government organisations

themselves who must redesign or re-engineer their internal data flows and processes. As Dodge and Kitchin (2013) warn crowdsourced geographic data in particular may always be a perpetually unfinished product. This is very different to the strict collect, check, analyse, report and distribute cycle which most government agencies (such as National Mapping Agencies) employ.

- **Governments and Communities: Understand each other** Brabham (2013) recommends that governments gain a better understanding of how crowdsourcing communities work. Haklay (2013) also recommends cultural change where the scientific community develops understanding and acceptance of CS and VGI in particular. Crowdsourcing communities must also gain a better understanding of the mechanisms and structures within which governments carry out data collection, analysis and reporting. This includes appreciation of the legal, ethical, security and privacy aspects of governmental data processes. In some cases, as outlined by Haklay et al. (2014) licensing and intellectual property rights (IPR) issues can cause barriers to participation by communities and update of crowdsourcing by governments. Communities involved in crowdsourcing should always be open and honest about their expectations, the tasks offered, and how they will treat the data they collect (Scassa, Lauriault and Taylor 2014). Government agencies that collect and/or distributes crowdsourced collected data must protect those data, as well as inform its users of how it will use that information (Wolfson and Lease, 2014).
- **Governments and Communities: Acknowledge participation** if government agencies decide to adopt crowdsourcing the significance of the contribution(s) provided by these communities must be acknowledged clearly and publicly (Haklay et al., 2014). The acknowledgement of participation could be realised through public announcements on websites, social media, in published material, etc. It could also manifest itself in financial or other remuneration of the citizens involved in the crowdsourced activities (Saxton et al., 2013). Proper and meaningful acknowledgement of participation will help create additional momentum for crowdsourcing activities to spread. Further, as in the case of cybercartography, it is about data provenance and also the recognition of the contribution of elders to the production of scientific knowledge. Crowdsourcing communities involved in government activities should also reciprocate the acknowledgement of their involvement in these activities and the assistance they have been provided with by the relevant government agencies.

As governments in many jurisdictions must now act within the constraints of reduced budgets and limited human resources CS, VGI and PM offer opportunities to include the public in data and information collection and analysis towards a more grounded approach to evidence-based decision-making. As we have described in the paper CS, VGI and PM have become normalised practices. There should be no surprise expressed at: the quantities of data and information these approaches are capable of collection, the size of the communities within each of these manifestations of crowdsourcing or, the quality and relevance of the data and information collected. Franklin et al. (2013) conclude that the future of GIS appears headed toward ways to exploit and consume free commercially and publicly available services that depend on crowdsourcing for their data and information. As we have shown in Figure 5 there is an implementation space within which these projects and services are positioned. Projects or services can be chosen based on their System Openness (Restricted to Open) and their Quality Control Formality (The Crowd to Professionals).

Not all types of geographical data and information are suitable for volunteer or crowdsourced data collection. As Wilson and Graham (2013) outline there are clearly limits to the kinds of geographic information that citizens can volunteer and crowdsourcing can collect. They use the examples of property boundaries and geodesy where instrumentation is complex and expensive and accuracy requirements are stringent. In particular in the kinds of geographical information where uncertainty is likely to be very high/large this is probably not the best type of geographical information for citizen volunteers to collect. Governments and their agencies will continue to be the authoritative source of data and information for these domains.

Martin (2014) argues, on a similar and related topic, that a successful Open Government Data (OGD) agenda must have the transformative impacts anticipated by the proponents of OGD by influencing the broader landscape. These transformative impacts will require breaking down of barriers in two forms: barriers to the opening of data being incorporated into the daily practices of governments (implementation barriers) and the barriers to individuals and organisations creating added value and social innovation through the use of OGD (barriers to use). As we have discussed in this paper the transformative impact of crowdsourcing as a means of improved public engagement will only be fully realised with the breaking down of these very same barriers.

Within government structures a windows of opportunity can emerge which can enable an innovation to breakthrough as predicted by Martin (2014) for the Open Government Data movement. These windows of opportunity open up as a result of tensions within the structures of the regime, or pressures exerted on the regime by the landscape. Social media, crowdsourcing, social networking etc. are these pressures exerted by the landscape within which government operate. This paper has provided a critical overview of how best to approach crowdsourcing geographic information and its potential as a tool for public engagement. Windows of opportunity are in view. We believe that there is great value in seeking these windows of opportunity offered by VGI, CS and PM for governments and public officials to keep databases up to date, to gain insight about natural resources and environmental conditions, to better understand the socio-economy of the people it governs and finally as a form of data-based public engagement.

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- *COST Action IC1203 European Network Exploring Research into Geospatial Information Crowdsourcing: software and methodologies for harnessing geographic information from the crowd (ENERGIC)* http://vgibox.eu/
- *COST Action TD1202 Mapping and the citizen sensor* http://www.cost.eu/domains_actions/ict/Actions/TD1202
- *Cybercartographic Atlases* https://gcrc.carleton.ca/confluence/display/GCRCWEB/Atlases
- *EPA Ireland Drinking Water Assessment* http://erc.epa.ie/water/wells/
- *ESRI Community Maps of Canada Program* http://www.esri.ca/en/content/esri-canada-community-map-canada-program
- *Flickr* https://www.flickr.com/
- *Flu Watch* http://www.google.org/flutrends/about/how.html
- *Foursquare* https://foursquare.com/
- *Galaxy Zoo* http://www.galaxyzoo.org/
- *Geocoder* http://geocoder.ca/
- *GeoGratis Portal* http://geogratis.cgdi.gc.ca/geogratis/Home?lang=en
- *Geonames* http://www.geonames.org/
- *Google Flu Trends* http://www.google.org/flutrends/
- *Mapping for Rights* http://www.mappingforrights.org/participatory_mapping
- *Marine Litter Watch*, http://www.eea.europa.eu/themes/coast_sea/marine-litterwatch
- *Mechanical Turk* https://www.mturk.com/mturk/welcome
- *National Biodiversity Data Centre (NBDC)* http://www.biodiversityireland.ie/
- *Notification Edit Service* http://nes.land.vic.gov.au/WebSite/Login.aspx?ReturnUrl=%2fWebSite%2fDefault.aspx
- *OSM Statistics* http://osmstats.neis-one.org/
- *Project Noah* http://www.projectnoah.org/
- *Safecast* http://blog.safecast.org/

- *Waze* https://www.waze.com/