Addressing Illegal Dumping with Web-Based Participatory Mapping

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Abstract

This paper addresses illegal dumping as an environmental and health concern and describes the factors leading to illegal dumping and threats caused by the resulting pollution. Barriers to mitigation of illegal dumping exist (such as lack of funding or poor education), however participatory mapping is being implemented world-wide as a tool to gather information about community concerns and to prioritize action on those concerns. Participatory mapping is now available in geo-referenced online platforms that increase accessibility to and functionality of participatory maps. Software choice should be based on audience, community needs, and project objectives in order to have the most successful result. This method has potential implications for quantifying illegal dump sites in Abaco, Bahamas to inspire political will, and for raising awareness of stakeholders about the impacts of illegal dumping to the environment and human health.

key words: illegal dumping, participatory mapping, GIS, PGIS

Introduction

What is illegal dumping?

Illegal dumping refers to the placement of any waste or restricted items in non-designated areas (US EPA, 1998). Illegal dumping often happens out of sight and typically consists of items that are difficult or costly to dispose of (Ichinose & Yamamoto, 2011; Tunnell, 2008; US EPA, 1998). Researchers have reported that illegal dumping occurs more frequently in poor rural areas and cite visibility and accessibility as key characteristics for predicting the location of illegal dump sites (Tasaki et al., 2007; Tunnell, 2008). Physical features of a place such as topography, the presence of roads and disturbed habitat edges, poor lighting and the proximity to established legal dumping sites and vacant land can be predictors for illegal dumping potential (Tasaki et al., 2007; US EPA, 1998). Propensity for illegal dumping can be further predicted by socio-economic factors such as education, limited access to waste facilities, crime and capacity of enforcers, and areas where residents have little investment in the local community (Ichinose & Yamamoto, 2011; Tunnell, 2008; US EPA, 1998). Anecdotal evidence for illegal dumping in Abaco, Bahamas suggests that dump sites are being contributed to by both domestic and commercial sources, however the extent of this problem is currently unknown (Appendix I). There is a need to quantify the number of illegal dump sites in order to report to government agencies and inspire political will for updated policies, increased management, and social change.

Threats caused by illegal dumping

Illegal dumping is a concern for all citizens because it contributes to degradation of the natural environment, it is a health and safety hazard, promotes proliferation of disease vectors and reduces property value (Project Greensweep, n.d.; Tunnell, 2008; U.S. EPA, 1998). Illegal dumping can have severe implications for human and environmental health (Tasaki et al., 2007). The sheer extent of illegal dump sites can reduce native biodiversity and contribute to habitat fragmentation (U.S. EPA, 1998). Some of the most common types of illegally-dumped items are appliances, construction materials, chemicals, furniture and old technology (Tunnell, 2008). Part of the reason these items may be dumped is because the owners do not know how to properly dispose of them or they are not accepted by normal trash pickup because they are either too large or hazardous (Tunnell, 2008, US EPA, 1998). Old appliances can be responsible for releasing pollutants into the environment. Examples include lead, which is known to contribute to birth defects, kidney failure, brain damage and reproductive impairment; clorofluorocarbons (CFC's) which contribute to depletion of the ozone layer; and polychlorinated biphenyls (PCB's) which are known to contribute to reduced immunity and cancer (U.S. EPA, 2013a and 2013b). In addition to the toxic nature of illegally dumped materials, unmanaged waste can also attract disease vectors such as rats and mosquitos (U.S. EPA, 1998). This is of particular concern in tropical and sub-tropical areas that are more susceptible to mosquito borne illnesses such as dengue, chikungunya and malaria (World Health Organization, 2014). Dumping can increase after hurricanes and other natural disasters due to property damage, a situation which can further increase the threat of vector-borne diseases (U.S. EPA, 1998).

Barriers to Mitigation

Areas experiencing illegal dumping are often faced with socio-economic issues that affect waste management and prevention of illegal dumping (Tasaki et al., 2007; Tunnell, 2008).While an integrated and cooperative management approach is needed, communities may be too disorganized or lack motivation to participate (Tunnell, 2008). Due to poor education, locals may be ignorant of existing legislation governing waste management as well as the potential impacts of illegal dumping (Tunnell, 2008). In order to mitigate against illegal dumping, fines need to be put in place and enforcement agencies need to monitor areas prone to illegal dumping (Tasaki et al., 2007). However, the reality is that many municipalities cannot afford to manage designated dumping sites, they do not have enough staff to monitor sites (whether legal or illegal) and human resources are often consumed in dealing with more severe crimes such as drug use and gangs (Tunnell, 2008; U.S. EPA, 1998). Cost is also a factor for the individual in deciding how to dispose of their waste (Ichinose & Yamamoto, 2011; Tunnell, 2008; U.S. EPA, 1998). Ichinose and Yamamoto (2011) suggest that a better network of waste management facilities can help reduce the cost of dumping and thus make it more likely that people will dump legally. However, infrastructure costs money too, so creative partnerships should be formed between the government and local organizations to make the best use of available resources (Steelman, 2002; U.S. EPA, 1998). Studies from Japan (Matsumoto & Takeuchi, 2011; Tasaki et al., 2007) and Kentucky, USA (Tunnell, 2008) demonstrate that many common barriers to waste management exist, but that there are also unique place-based issues to consider.

Breaking down the barriers

A user-friendly, cost-effective, collaborative solution is needed to address illegal dumping around the world. With any conservation planning it is important to consider a solution that fits the unique nature of a community and the issues it is facing (Waylen et. al., 2010). Additionally, conservation projects can be more effective when there is an outreach component and community members are encouraged to actively participate in the project (Reed, 2008; Waylen et. al., 2010). The purpose of this paper is to investigate the use of web-based participatory mapping software for the collection of data by stakeholders on environmental concerns such as illegal dumping. Once collected, this type of data can be used to inspire change in policy, management and social behavior. There is a need to quantify and identify illegal dumpsites in Abaco, Bahamas to help illustrate the severity of local waste management issues (see Appendix I for examples).

Discussion

Participatory Mapping

Participatory mapping provides stakeholders with the opportunity to increase their involvement in a project by sharing ideas and experiences (Bateman et al., 2002). By involving the community in mapping projects, the government can help avoid unrest and misunderstandings caused by lack of information and poor communication (ESRI, 2012). Participatory maps can be as simple as lines drawn on the ground with a stick, or handmade 3D versions of a town, or as complicated as a multi-layered geo-referenced map and can involve

various levels of participation (Bateman et.al., 2002; Chambers, 2006; Kingston, 2007). There are many ways to implement participatory mapping, but it is clear that strong community involvement is key to achieving an accurate and usable product (Chambers, 2006). Illegal dumping is such a large issue worldwide, the ability to map it out and visualize the problem could help governments and local management agencies identify problem hotspots and prioritize action (Tasaki, et al., 2007).

Solutions in Software

Geographic Information Systems (GIS) is the parent software that makes much of digital participatory mapping possible. GIS is thought to have been developed primarily in North America in the 1960's and experienced many stages of growth through its use by agencies such as the U.S. Geological Survey (Coppock and Rhind, 1991; Dunn, 2007). However, until recently, the use of GIS-based technology required powerful computers and specific technical knowledge not available to the everyday person (Kingston, 2007). Due to the rapid nature of technological progress and open source software development, GIS tools are now available to the general public through web-based software programs (ESRI, 2012; Kingston, 2007). According to Goodchild (2000, p. 6), GIS "captures, stores, manipulates and analyzes spatially referenced data". Participatory mapping with GIS (Participatory GIS or PGIS) can make use of those qualities by simultaneously investigating multiple features of the natural and social environment such as attitudes, location and environmental health, and by contributing to spatially-linked decision making (Bateman et.al., 2002; Dunn, 2007; ESRI, 2007). Through visual mapping, GIS can provide a common language between stakeholder groups to encourage communication and

data sharing (ESRI, 2007 and 2012). PGIS can be accomplished by incorporating paper maps from a community workshop into GIS by an expert, or by having the stakeholders enter the information directly onto a web platform (Dunn, 2007).

Web-based Participatory Mapping Software

Web-based participatory mapping software (WBPMS) has now been adopted by municipalities around the world as a means to gather data from citizens in order to improve the health and management of cities (Dunn, 2007; Kingston, 2007).Web-based participatory maps and their associated programs and applications help to solve the need for community monitoring by overcoming shortfalls in government and organizational staffing because citizens now become the eyes and ears of the operation (ESRI, 2012; Steelman 2002; U.S. EPA, 1998). There are some ethics involved in ensuring that the people providing information for participatory mapping are not negatively affected. For example, maintaining anonymity when sensitive issues are being reported, which is much easier to facilitate on a web-platform versus during a public meeting (Kingston, 2007). It is critical to ensure that the maps are presented in a format that the user can understand and that they have access to (Chambers, 2006; Dunn, 2007; Reed, 2008). The internet is public domain, so this greatly increases the distribution of information collected through WBPMS; this can also be a criticism because as of 2012 only one third of the world's population was using the internet (Internet World Stats, 2013). However, approximately 61% of Bahamian residents have access to internet through various sources such as mobile devices, schools, and private locations, whether at home or at a friends house, so this is a feasible option for The Bahamas (Department of Statistics of The Bahamas, 2012a & 2012b).

Addressing a Problem

The activity of mapping leads stakeholders to believe that there will be a resultant benefit (as there should be) so there needs to be a project manager behind the mapping project who is responsible for following up with stakeholders and ensuring that the maps are used for their intended purpose (Chambers, 2006; Dunn, 2007). This can be facilitated through a function of WBPMS that directs reports to the necessary department and sends automated responses to participants letting them know that their report has been received (ESRI, 2012; Kingston, 2007; see Table 1). In The Bahamas this map-based information could be used to generate reports for government agencies responsible for managing waste and environmental health. Long term data collection could also help to identify patterns in illegal waste disposal and track failures or successes of conservation programs targeting these sites and the stakeholders relevant to them. A comprehensive awareness plan is needed to promote the mapping facility and encourage participation; options for Abaco, Bahamas include Facebook, community websites, local and national newspapers, as well as letters inviting community groups and businesses to participate.

Characteristics of illegal dumping sites to consider for WBPMS

In order to gain a full picture of the social, environmental and health issues related to illegal dumping a suite of questions should be answered as part of the mapping process. Tasaki et al. (2007, p. 257) point out that both the “occurrence and size” of dumping sites can be used to determine the extent of the problem. Ichinose and Yamamoto (2011) suggest that the size of dump sites is hard to quantify (by volume) so the number of occurrences may be the most reliable measure even if it may not accurately depict the full severity of illegal dumping in the

study area. Key to the method of WBPMS is marking the location of the illegal dump sites, which can be done in real time with the use of mobile phones or tablets (ESRI, 2012; see Table 1). Denoting the type of trash present at the illegal dump site can help managers better understand the threat to the environment and human health and come up with a plan to clean up the area. It would be useful to include additional factors such as whether the dump site appears to be active and any visible impacts to the surrounding areas. Mapping all of these characteristics will enable future investigations to relate the positioning of illegal dump sites to communities, major roads, actual dumping facilities, and even socio-economic factors (Tasaki, et al., 2007; Tunnell, 2008).

Matsumoto & Takeuchi (2011) describe a broken window effect with illegal dumping, where people are more likely to dump if someone has already littered in the area. By identifying and addressing illegal dump sites it may be possible to prevent further dumping. Being able to prioritize action on illegal dumping sites based on environmental and health threats as well as feasibility for restoration is a beneficial feature for governments and non-governmental organizations who work on budgetary constraints (Tasaki et al., 2007).

Table 1. SWOT Analysis (strengths, weaknesses, opportunities and threats) of the benefits of web-based participatory mapping software for use in management of illegal dumping using a selection of examples.

	Strengths	Weaknesses	Opportunities	Threats
Google Maps Engine Lite	- Free - Able to import location data you have already collected - Can invite collaborators - Layers feature to group types of content - Ability to change the base map - Mobile app accessible	- linked to personal email address - Android mobile Operating Systems only - limited structure for collecting multiple data points per location (only has a comment box)	- Government agencies and other groups may have existing information on illegal dumping which can be imported	- Designed more for personal, rather than community use
Ushahidi	- Free - Open source - Able to receive information from multiple sources - Can be imbedded in a website - Works with data from texts, emails, twitter and web-forms - Data can be exported	- May require some technical knowledge to deploy	- Takes advantage of phone service when internet isn't available - Can sort data by time to look at trends in dumping - Accepts photos and video to provide more details on illegal dumping reports - Can be used anywhere	- May require some technical knowledge to deploy

	Strengths	Weaknesses	Opportunities	Threats
Priority Mapper (InfoHarvest, Inc).	- Incorporates prioritization, decision management - Works with GIS	- An ArcGIS add-on which requires technical knowledge as well as experience with budgeting and costing for project management.	- Enables managers to weigh the pros and cons of restoring particular sites.	- Data entry and prioritization is done by a manager, rather than a stakeholder. Workshops could be held to get local perspectives on prioritization. - Not user-friendly for the general public.
Healthy City (www.healthycity.org)	- designed with social change in mind - user-friendly - users can upload and share data	- limited datasets (but open to suggestions for inclusion)	- Organization provides support for a well rounded web experience	- currently restricted to California
Mobile City Hall citysourced.com	- Mobile platform available for Android, Blackberry, iPhone and Windows - Integrates easily with GIS - Hosted in the cloud - Free download	- Information not currently available for all areas.	- Automated message sending notifies stakeholders of relevant issues - Photos linked to reports can lead a manager directly to the problem	- US-based only (restricted in some areas)
ArcGIS Online (ESRI, n.d.)	- Free - No download required - Ability to change the base map and explore ESRI provided layers	- Limited flexibility in terms of modifications -	- Maps can be shared and combined with those created by others - Useful apps such as “Collector for ArcGIS” (paid subscription only)	- Limited cloud storage - More appropriate for use at an organizational, rather than community level

* See References at end of paper for links to the web-based participatory mapping platforms described here.

Conclusion

Illegal dumping is a multi-faceted issue that requires collaboration on local and national levels with partners from communities, organizations, businesses and governments. There are many physical needs to address illegal dumping such as equipment, funding and human resources; however these needs can be addressed more efficiently through participatory data collection and mapping. Paper maps could be sufficient in some cases; however, digital web-based geo-referenced maps provide exponentially more flexibility in terms of data collation, sharing, analysis and access.

Participation of community members in a mapping project gives them a greater stake in the project and helps to facilitate outreach. An analysis of available types of web-based participatory mapping software demonstrated the diversity of products on the internet as well as the pros and cons of their use in identifying sites of concern for illegal dumping through community reporting. This is not an exhaustive list, but it represents the most commonly searched options. Ushahidi appeared to stand above the others as a flexible user-friendly platform that is easily accessible and usable by people all over the world.

Considering the availability of internet connections in The Bahamas and the open platform design of Ushahidi, it could be a suitable option to collect information from the Abaco community about illegal dump sites. For organizations or individuals wishing to mobilize web-based participatory mapping software for use in collecting data about environmental threats it is suggested that a SWOT analysis be done to tease out the advantages and disadvantages of each program, then pre-testing of the software will help to determine if the program is appropriate for

your audience. Throughout the development process it is key to plan with your audience and project goals and objectives in mind.

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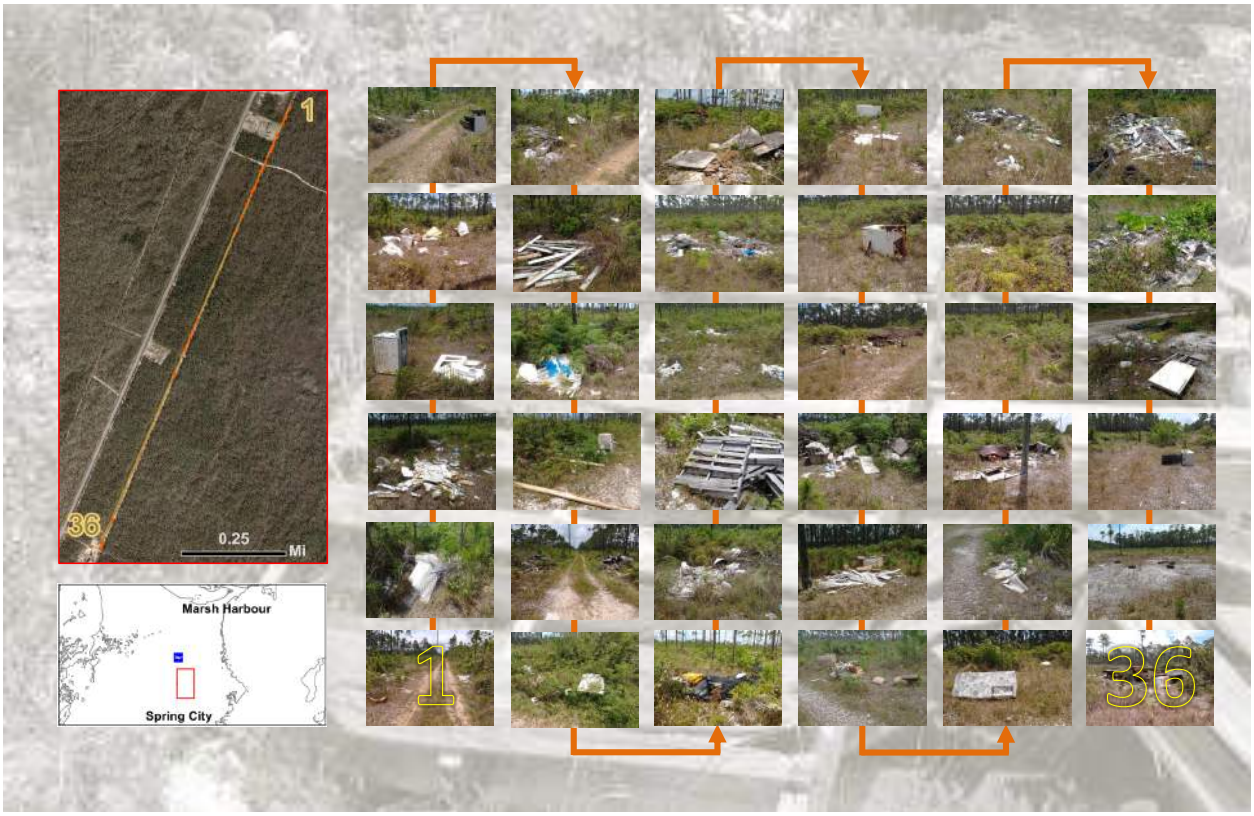
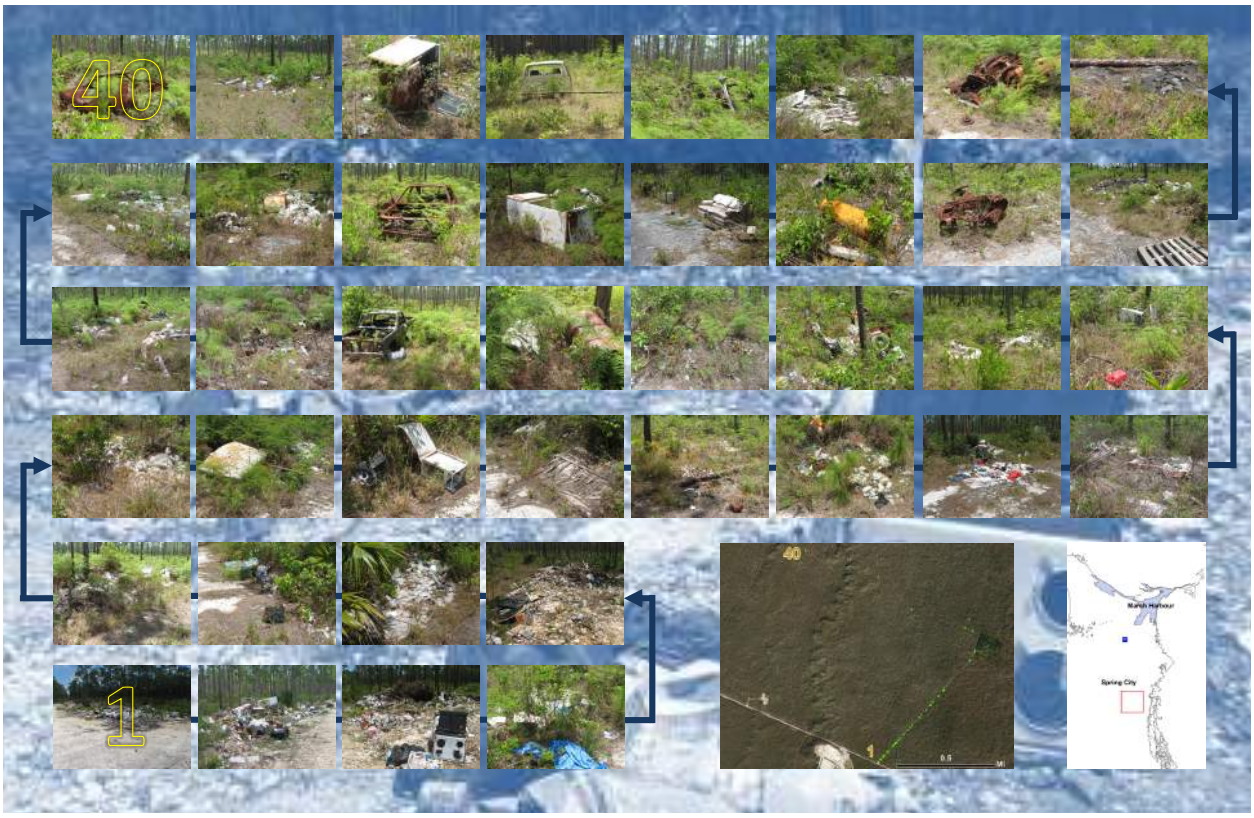
Appendix I

Three transects showing a total of 118 illegal dump sites near Spring City, Abaco, Bahamas

(photos taken in 2013 by Marvin Russell)

Approximate location: 26.4777°N, -77.0980°W

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