Wastesites.io: Mapping Solid Waste to Meet Sustainable Development Goals

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Abstract

The World Bank has conservatively estimated that 33% of global waste is managed in an environmentally unsafe way (Kaza et al. 2018). Waste generation could nearly double by 2050 with generation per capita expected to increase by 40% in low- and middle-income countries, many of which are growing at an unsustainable pace with limited resources dedicated to waste management. YouthMappers creating local geospatial data about sites of illegal trash dumping can play a key role in mitigating impacts and improving waste management, and in turn, impact public health. Several of the UN SDGs are supported by creating and sustaining a clean, healthy environment, particularly in this case, SDG 12 Responsible Consumption and Production and ultimately, SDG 3 Health. A novel tool, Wastesites.io, has been initiated to leverage youth action and connectivity of YouthMappers in order to solve these challenges together.

Keywords

Responsible consumption · Waste · Mapping apps · Kenya · Zambia · Nigeria · Public health

1 The State of the Trash Problem

Virtually every person and human activity generates waste in some form or another. While certain countries have reliable municipal or private

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waste services, many do not. Developed countries have national policies and entire agencies dedicated to monitoring and improving the environment, with waste management being an essential service. The impact improper waste management has on human health, water quality, air quality, and overall life on land and water has been well researched and documented. Accurate data are a key component for managing resources and measuring human and environmental health (OECD 2019). Unfortunately, quality data to support proper management is lacking in many places around the world. Timely and accurate data are needed to track the quantity, composition, and type of materials being consumed by humans. Each city and location requires information unique to that location to understand the effect of waste on humans and the environment and offer insight into potential solutions (Ejaz et al. 2010).

1.1 Missing Location Data for Waste Site Management

The absence of detailed data to help manage solid waste is inherently a geospatial problem. All waste is generated in one location then transported through a series of bins, dumpsters, trucks, or transfer stations, ultimately ending up in a landfill, incinerator, or processing facility. The adoption of geospatial technology in this industry is lagging, and without a comprehensive database of supporting infrastructure, it is impossible to plan and develop an efficient system for proper management.

In the United States, it took until the 1950s for the government to begin examining legislation and policy to reduce solid waste emissions (Hickman 2000). Up until then, open burning pits were commonplace across the U.S. and hazardous byproducts from industrial pollution were regularly dumped into local waterways, which is still common practice throughout the world. Public health impacts are well known, particularly the impact on air and water quality. A pinnacle turning point in the U.S. occurred along the Cuyahoga River in Ohio which caught on fire several times from oil slicks and pollutants floating on the surface. The economic impact of these fires caught the attention of local and federal government officials and was used to campaign for stricter regulations.

Eventually, in 1965, the Solid Waste Disposal Act (SWDA) was passed as an Act of Congress which is described as "the first federal effort to improve waste disposal technology." The Act set safety standards for landfills and established a framework allowing states to create independent standards unique to their needs. More importantly, the SWDA created a system to gather information about existing infrastructure. Officials needed information such as the location of landfills, open burn pits, and factories. These data allowed insight into the industry, the amount of waste being generated, impacts on the environment, and potential reductions and improvements to the amount of waste being generated. In 1970, the Environmental Protection Agency (EPA) was launched, which helped improve waste monitoring and research. The EPA established environmental baselines to measure the success or failure of different management practices. From there, the Resource Conservation and Recovery Act (RCRA) was created and became law in 1976. It remains the primary law governing the disposal of solid waste. The Act has been amended several times to accommodate for changing demands, amounts, and new types of waste. This example highlights the framing role of policies within waste management which is essential to establishing laws to protect human and environmental health, in turn affecting these SDGs.

Proper waste management takes a series of resources to be accomplished successfully. These resources include government funding, built infrastructure such as paved roads, large trucks, and equipment, along with a population willing to implement sound practices. The fastest-growing cities in the world are all within developing countries and lack resources to accommodate this surging population. As people migrate toward

urban areas for work, waste management becomes worse each day. UN-Habitat estimates that 25% of the world's urban population live in informal settlements (Avis 2016). In some cases, city governments attempt to evict residents of informal settlements while other times they are tolerated but ignored with no access to municipal services. The preferred approach is for governments to work with residents to help secure land tenure rights and integrate them into urban society. It is impossible to accurately create municipal budgets and plans to support populations without timely and accurate information.

1.2 The Open Spatial Data Opportunity

Today there is tremendous opportunity to improve waste management policy and regulation throughout the developing world using geospatial tools. Not all waste requires the same regulation or management process. Sources of waste can be classified into four broad categories: industrial, commercial, domestic, and agriculture. This research focuses on creating geospatial data to better manage household-generated domestic waste. It is necessary to understand changes in production and consumption for local authorities to develop strategies for proper collection and disposal of waste. Many countries lack basic information needed to manage waste such as addresses, complete road networks, and the location of waste facilities and informal dump sites. With the exponential increase of solid waste these data are necessary for governments to understand and plan future investments keeping people and the environment clean for generations to come.

Fortunately, maps and geospatial data are more accessible in today's world than any other time in human history. Satellites are constantly orbiting earth snapping images to monitor the changing landscape of our planet, smartphones allow users to easily navigate cities and populated areas discovering places of interest and other essential services. Researchers are constantly finding new methods, tools, and communities to engage and benefit from technological advancements. Accessible and accurate data are the foundation for improving waste management and planning for future demand.

All the tools and technology needed to support an operational and efficient waste management system exists; however, there are many barriers in employing technology to make smart decisions. Government regulations and financial costs are high on the list. The first step in moving toward technology- and data-driven approach is improving the accessibility and quality of geospatial data for features essential to waste management. It is the first step in addressing this challenge at a global scale.

2 Case Studies of Mapping Solid Waste

YouthMappers around the world have been innovating to help fill in missing data for waste management, using the tools of OSM and local fieldwork to make a difference breaking the consumption cycle, and building better health for their environment and local populations. These cases narrated below represent only a few examples among many and have served as independently designed, serendipitous, and organic movements to use geospatial tools and ideas to address SDG 12 and SDG 3 in different local contexts. They share at their heart, a commitment to responsible production, healthy communities, and youth action.

2.1 YouthMappers in Nairobi, Kenya

Acute growth and rapid urbanization in Nairobi Metropolis, the heart of Kenya's economy, has led to the rise of illegal waste disposal which has become a major threat to the city and environment. Cases of epidemics like cholera have been reported in areas nearby landfills and disposal areas. In 2020 the Nairobi population was 4,735,000, a 3.93% increase from 2019.

Industrialization and urbanization associated with rapid urban growth at this scale are exponentially increasing the generation of solid waste throughout the city. There is a need for the evolution of Kenyan culture to develop spatial data improving economic, political, and social development. There is a growing need for both accurate and open data at both government, private institutions, and the local community level. This project will help Kenya meet Sustainable Development Goals (SDGs) that exist within institutions and government.

Effective solid waste management is essential to maintaining a healthy population and environment. Many low- and middle-income families have little to no municipal services to properly dispose of solid waste. This often leads to unpleasant neighborhood waste piles putting residents at risk of contaminated drinking water, disease-carrying rodents, and poor air quality causing refuse to regularly flow into waterways and forcing residents to organize periodic burns (Fig. 20.1).

The objectives outlined in this project contribute to achieving Kenya's Vision 2030 by promoting a healthier environment, empowering Youth to promote their own social and economic development, building more resilient people and ecosystems in a green growth economy, and creating an enabling environment for private sector investment in solid waste management. Several Sustainable Development Goals (SDGs) are supported throughout this work as we focus on collecting data to create a cleaner and healthier ecosystem.

This overall goal of this project is to increase data availability and accessibility for the government and solid waste industry in Nairobi by mapping formal and informal waste sites. Having data on where resources and threats to the environment exist is the first step toward planning improvements to the existing system. Training and field mapping exercises will help strengthen data literacy while providing youth and community members the opportunity to gain valuable workforce development experience.

2.2 YouthMappers in Lusaka, Zambia

Most cities in sub-Saharan Africa are growing at an unsustainable rate. Lusaka is the capital and largest city of Zambia and happens to be one of the fastest-growing cities in Southern Africa. As of 2019, the city's population was about 3.3 million, up from 2.5 million in 2018. According to Lusaka City Council (LCCS), 70% of solid waste

Fig. 20.1 YouthMappers at the Dedan Kimathi University of Technology help to remove waste at a site near Nyeri, Kenya

is generated from peri-urban areas in Lusaka, and half of it remains uncollected. The uncollected solid waste has a negative effect on the health of the people, at times this solid waste blocks the water deranges hence coursing floods in the city during the rainy season.

Waste collection and management are vital public services for every community and are obligatory for the protection of public health and the environment. Quality waste management services are important to urban management and policies; they fortify thriving local economies and are essential to ensure the protection of public spaces.

Sustainable Development Goals (SDGs) cannot be achieved if waste management is not prioritized. It poses a risk to the well-being of the people, when people have good health the productivity of a country can be attained. Zambia has a vision for 2030 to shift from a developing nation to a middle-income country, for this vision to be achieved a key consideration is to ensure the environment is clean and free from any illnesses that can emulate from a polluted environment.

Solid waste management has been a challenge for the Local authority in Lusaka due to the overpopulation of peri-urban areas. Most of these areas are too big for effective collection of solid waste and there is a lack of supporting geospatial data. YouthMappers took part in a project to map the zones for solid waste. During the data collection exercise by YouthMappers at the University of Zambia (UNZA) chapter, students were able to map boundaries for the solid waste zones in 6 peri-urban areas, identify the major road networks in these peri-urban areas, and identify the location of dumpsites to study the accessibility of these sites by waste collection vehicles (Fig. 20.2).

Having detailed maps for each zone provides the council with information to enable planning for future waste management efforts. It allows them to study the amount of waste being generated for each area, research different interventions to improve management, and ultimately help improve the health of people and the environment.

2.3 YouthMappers in Akure, Nigeria

YouthMappers in Akure have been shocked by the amount of pollution he found in this big city in southwestern Nigeria. They were surprised to see trash piled high in the streets of neighborhoods across the city. Due to poor infrastructure and a lack of policy and regulation on trash collection, informal dumping sites, and poor waste

Fig. 20.2 YouthMappers from the University of Zambia pinpoint waste sites in Lusaka, Zambia

management created a large urban waste problem (Blevins and Lefeber 2018). Without anywhere to go with their trash, most households just contribute to the issue, piling waste around their neighborhoods (Oniosun et al. 2020; Oniosun 2017).

Akure's mounting urban waste problem is not just unsightly – it poses significant health, sanitation, and environmental consequences for the community. Though tackling this challenge is no easy task, YouthMappers at the Federal University of Technology were motivated to find a way to clean up their city. As students taking the remote sensing and Geographic Information Systems (GIS) major, the chapter decided to put their mapping skills to work to take on the challenge. Forty students from across the university began mapping urban waste across the city (Figs. 20.3 and 20.4).

Clearly, many of the problems African nations face could be addressed with better information – and mapping adds an important dimension to this. Spatial data can help deal with issues such as desertification, water resources, locust plagues, planning and urban development, and monitoring the latter's impact on biodiversity. But all of these also depend on human activity in the production-consumption cycle not leading to poor environmental sanitation. According to the Active Times, out of the World's 25 dirtiest cities, 16 of these are from several countries in Sub-Saharan Africa. The initiation of the Urban Waste Mapping project by the YouthMappers chapters in Akure, Nigeria set out to address this. We all know there is trash everywhere in our city, we see it every day, but in order to clean it up, we first have to get a clear picture of the situation. YouthMappers first mobilized students at universities around the world to help remotely create new geospatial data using OpenStreetMap – to accomplish base maps of streets and buildings. Sitting at computers with satellite imagery of Akure as the backdrop, students from around the world digitally mapped roads, buildings, and parks in the city that had never been mapped before.

In the YouthMappers chapter of the Federal University of Technology, Akure decided to focus from the field on identifying illegal dumping sites in the city. Armed with this new base map of the city, YouthMappers hit the streets of Akure on bicycles and motorbikes to identify the location of illegal dumping sites. Students recorded GPS coordinates, descriptions, and photos for each site they found.

About 40 volunteer mappers collecting necessary street-level data. KoboToolBox was used to collect information such as: pictures of the dump-

Fig. 20.3 YouthMappers from the Federal University of Technology take to the streets on their bicycles to map waste in Akure, Nigeria

Fig. 20.4 Illegal waste sites exacerbate public health, infrastructure, and water quality or flooding problems

site, coordinates, site descriptions, type of waste (special waste, liquid waste, hazardous waste, restricted solid waste, general solid waste [Putrescible], general solid waste [Non-Putrescible]), proximity to residentials or water bodies (<10m, 10–30m, 30–80m, 80–150m, >150m), size of site and accessibility (either motorable or not). Navigation through the city for data collection was done using motorcycle/bodaboda/okada while the processed information was made available openly on Umap.

One major issue faced during mapping involved residents of some areas being concerned about why we are taking pictures and collecting data at each site. This provided a good opportunity for environmental outreach, sensitizing people about why they need to keep their environment neat and keep away from illegal dumping of refuse. The students ultimately proposed more suitable locations for disposal facilities away from residential areas and water sources. It wasn't enough for us to simply map illegal dumping sites, we also needed to give solutions to the problem. So the project output was presented to Ondo State Ministry of Environment to inform urban waste policy planning and also serve as a resource for local NGOs that work on urban waste clean-up. It was also later transposed to other cities toward environmental sanitation and became a chapter in a book authored and edited by the YouthMappers leadership.

But perhaps the most important reason to map is to spread the message. If seeing is believing, then looking at a virtual map of overflowing trash sites will help open our eyes to the problem. And, hopefully, it will also inspire people to join us to do something about it so we can look forward to a cleaner city (Oniosun 2017).

3 Wastesites.io: A Solution for the Global Goals

These case studies showcase the passion and power of today's Youth in addressing the SDGs. There is no shortage of volunteers or energy to engage in activities to improve environmental and human health. Over the course of several years, each of these projects evolved independently from one other, but serendipitously to address the same exact problem: the abundance of waste in the human environment. There are two critical factors that should be considered when looking at this kind of action as potential solutions for the SDGs.

First, youth action around trash occurs in the context of solid waste policy. It is important to recall that when the U.S. first addressed waste at a national level, the first step was enacted by Congress approving the Solid Waste Disposal Act. This in turn set loose a wave of regulation to basically collect and create data surrounding waste management throughout the country at local and regional scales. However, the work of YouthMappers chapters is unfolding in very different policy environments, especially in places where regulation just does not exist or is not enforced. Part of the power of this work is that it can bypass a lack of regulation, by creating data to directly address the problem. Often it takes a grassroots movement to influence national-level policy change. Mapping waste can be seen as a lever of engagement where citizens take responsibility for their own sites and actions by bringing public attention to local concerns, with the added aim of persuading decision makers to enact policy to solve problems in favor of their constituents – and ultimately in support of SDGs.

A second important aspect of this work is related to the potential for scaling up solutions across many different communities facing common problems. Each of these projects may appear small but combined they bring a greater level of attention, a robust model for working through common challenges, and importantly, the connectivity of a network of youth bringing together like-minded individuals. To build upon this youth action and advance the impact and scale of work exemplified by the case studies in this chapter, solutions need to be designed that consider the data-policy context, as well as the opportunity for establishing and nurturing a growing community of practice (Blevins and Lefeber 2018).

Wastesites.io is one such solution potential. Wastesites.io has been conceptualized and initiated to support these efforts by building a virtual community around waste feature mapping. The

goal is to provide a platform for capturing data not only to visualize or highlight the problem but also to help solve the problem. Organizing and implementing field-level mapping campaigns takes an immense amount of work and a multitalented team. Wastesites.io aims to lower the barrier of entry for students and fellow community members interested in promoting responsible consumption while fostering a healthy environment. While each case study showcased here was unique, many of the same tools and methods were used to achieve results.

Mapping waste features in developing countries introduces a host of variables which make creating standard collection guidance difficult. The informal waste sector is one example, as seen in YouthMappers efforts. Many times, what someone may view as an informal dumping site is, in a practical place-based sense, the locally-understood formal spot where people have been and will be dumping their waste, often due to lack of alternatives. Basic guidance for designing and applying a mapping schema to cover each scenario is important and small distinctions occur at the hyper local level. While these results differ, what the YouthMappers' experiences underscore is that the process is very, very similar.

Clearly, proper waste management addresses multiple SDGs with goal 12 "Responsible Consumption and Production" likely being the most influential for countries like Kenya, Zambia, and Nigeria. But while waste represents the ending stages of the productive cycle, the question of how YouthMappers everywhere will continue to innovate and evolve such grassroots work could also take a focus on the production side, in higher GDP countries, where YouthMappers are also concerned about what the SDGs mean for them. For instance, while the United States has a high-functioning waste management system, the country overall ranks number one in waste generation (Tiseo 2020). When compared to lower GDP countries, the U.S. creates a disproportionate amount of waste per capita by a factor of more than 10 times. "Reduce, Reuse, Recycle" is a familiar quote used to demonstrate the power of behavior change. The kinds of tracking of data and location that solutions like Wastesites.io could offer include opportunities for all YouthMappers despite their local policy context, to unite and share around common problems, even if at first, they do not look similar. This could also happen because many of the same solutions for responsible waste management could be put in place wherever there is human production and consumption. One example of this solutions-driven principle is illustrated by the fact that many places around the world are embracing these words by banning the use of plastic bags. It takes the attention of politicians to implement bans like this with small costs for big returns in the solid waste system, and countries with lower GDP are leading the way, having implemented them for years, whereas countries like the U.S. are just now starting to put in partial, local effect. The relevance of a global community of practice cannot be overstated.

In conclusion, the YouthMappers experience with waste sites, represented by these three use cases, may seem small when compared to the global solid waste management crisis. However, each incremental step moving toward a solution is helping improve the health and well-being of local residents while contributing more broadly to a global capacity to address the SDGs. We aim to keep innovating, sharing, and building the network and tools to accelerate this work.

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