Reducing the impact of Solid Waste Management for communities in Nigeria using geospatial analytics

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Image source The Guardian Nigeria

Background

It is widely established that effective management of solid waste has been a global problem. In developing countries such as Nigeria, the impact and effect of ineffective solid waste management systems is a bigger concern. According to Chinedu (2018), waste generated in Nigeria is estimated at an average of 42 million tonnes annually. This is more than half of the 62 million tonnes generated in sub-saharan Africa annually. Hence, there is a need to understand the impacts of solid waste generated and how these impacts can be reduced.

Solid wastes are mostly generated by human activities (Brunner and Rechberger, 2014) and this has existed as a major source of concern since pre pre-historic period (Chandler et al, 1997). However, due to increase in rural-urban migration, the rate and quantity of waste generated in urban centres has increased beyond the coping mechanism of cities thereby increasing the environmental and health concerns. The bubonic plague epidemic that hit the city of Lagos in 1924 having a death rate of about 80% (1,813 deaths out of 1,947 cases) is a clear example among others of the need to consider the environmental and related health concerns of indiscriminate disposal of waste in dump sites (Faleye, 2017).

Concept of Solid Waste and Dump sites

Solid waste is the term used for non-liquid waste material produced as a by-product in domestic, commercial, Industrial and agricultural activities. According to Ibrahim (2002), the solid wastes are categorised into three broad types based on composition:

1. Biodegradable
2. Semi-biodegradable
3. Non-biodegradable

For achievement of an effective solid waste management system, one the major challenges that needs to be addressed as highlighted by Habiba et al. (2019) is the selection of appropriate disposal/dump sites. There has been research in the application of GIS in selecting appropriate dump sites for effective waste management. For example Eberechi and Godwill (2016) analysed dump site selection in ile ife, Nigeria considering four geospatial input data as a criteria: distance, slope, soil, geology. Mussa and Suryabhagavan (2019) developed a GIS based multi-criteria spatial modelling to assess the suitability of dump site selections in Logia town, Ethiopia. Other studies have also explored the impact of other criterias such as groundwater well points, slope, fault, built-up area, road network, river, land-use/land-cover, geology and soil map (Mussa and Suryabhagavan, 2019; Habiba et al.,2019).

A challenge of using these already existing approaches is that these methods rely mostly on earth observation and remote sensing data sources which are often coarse in resolution. Also, they have not explored at a high resolution the population at risk from the negative impact of improper dump site location. Methods must therefore be developed that considers these identified gaps especially in low and middle income countries like Nigeria.

This document explains how we propose to apply geospatial analytics to assess the impact of solid waste management for communities in Nigeria with an intent of reducing the identified impact. We also outline herein how we aim to assess the concept on a small scale to understand the wider use of the idea for Nigeria.

The Proposal

There are three key questions that have been identified to be addressed in this research and help policy makers in Nigeria make the best decision on the most appropriate location for a dump site considering the impact on communities.

1. Identifying the most suitable location for siting/relocating solid waste dump sites within communities
2. Evaluating the negative impact averted from population at risk close to solid waste dump site within communities
3. Identifying the mitigative measures for existing dump site within communities that are unlikely to be relocated
4. Identify the most suitable end to end waste management system for communities

It is expected that answering these questions will proffer a timely solution to the problems associated with the indiscriminate dumping of solid waste in the study area and serve as a model for other parts of the country. The problem of unhygienic dumping of solid waste at close proximity to humans is evident in most Nigerian cities. A perfect example is Olusosun Landfill, Onigbongbo, Lagos. The major beneficiaries of this research would be humans as a whole and most especially communities and houses close to major dump sites and recycling plants. It's all aimed at ensuring a cleaner and healthier environment for us all. However, If the beneficiaries are to be classified, they would be:

- **Government policy makers:** they need information on which dump sites are potentially a health hazard to the local population and evidence to inform their policy.
- **Dump site operators:** interested in knowing where they could dispose of waste without causing health impacts to local communities
- **Local population:** local communities may want to assess how "at risk" their area is from the local dump sites. By knowing this, they will be able to form community action groups to pressure the dump site owners to change their behaviour,

Data Collection

The baseline data to be used in this analysis are population and dump site locations. These datasets are available through the GRID3 Nigeria data portal https://grid3.gov.ng/ and also comprehensive and freely available for use which make it the most appropriate for use in this analysis.

Analysis

An initial proof of concept analysis has been carried out using the GRID3 population estimates and dump site locations for Lagos state. The number of people within a 5km buffer distance of dumpsite locations has been calculated using zonal statistics. This can give an insight into the proximity of the population to dumpsites, and enable potential further analysis and decision-making on identifying new locations for dumpsites where there are less people. The basic analysis was carried out utilised QGIS. Buffers were produced around all dumpsite locations in Lagos to determine their proximities to each other, population and other infrastructure. The buffer range of 5km that was used was based on the National Environmental Standards and

Regulations Enforcement Agency (NESREA), which stipulates a distance of 1000m from built-up residential areas. Also a distance of 500m from major roads and 250m from waterways (Aderoju et al. 2014). A distance of 5km was decided for this initial proof of concept so it can cover for both residential areas and major roads as well as waterways in one initial attempt.

Using QGIS and tutorials from the GRID3 QGIS training guide, the analysis followed the steps outlined below:

1. **Buffer Analysis**: Creation of buffers around locations of dump sites in Lagos according to a set distance.
2. **Zonal Statistics**: Calculation of the number of people within the buffers using zonal statistics, to find out how many people live within a certain distance of dump site locations.
3. **Visualisation**: Visualise the results in maps and tables, to identify areas where there are the most people in close proximity to dump sites.

Results

The results below show the figures produced from the analysis. Table 1 shows the number of people within 5km of a dumpsite location. Dumpsite locations have been visualised (Figure 1), along with their 5km buffer zones (Figure 2) and the number of population that fall within those buffer zones (Figure 3).

	dumpsite_c	name	dumpsite_t	source	ward_name	lga_name	state_name	ZS_sum	ZS_mean
1	Mixed Dumpsite	1st Avenue Dumpsite	Unofficial	GRID	Ilogbo	Badagry	Lagos	27530.99657106...	70.77377010556...
2	Mixed Dumpsite	1st Avenue Road Dumpsite	Unofficial	GRID	Ilogbo	Badagry	Lagos	27336.43150377...	68.17065212910...
3	Mixed Dumpsite	1st Gate	Unofficial	GRID	Ifelodun	Amuwo Odofin	Lagos	34273.94018924...	139.3249601188...
4	Mixed Dumpsite	1st Gate Dumpsite	Unofficial	GRID	Kuje	Amuwo Odofin	Lagos	34172.88905251...	120.7522581360...
5	Mixed Dumpsite	6th Avenue Dumpsite	Unofficial	GRID	Ilogbo	Badagry	Lagos	29641.52382385...	72.29639957038...
6	Organic Dumpsite	A Oj Sunmonu Street	Unofficial	GRID	Agbala/ Lasunwon	Ikorodu	Lagos	25876.65715295...	78.17721194244...
7	Organic Dumpsite	Aanu Oluwa Street Dumpsite	Unofficial	GRID	Ibereko	Badagry	Lagos	24892.83729422...	63.01984125119...
8	Mixed Dumpsite	Abiodun Aroga Dumpsite	Unofficial	GRID	Ilogbo- Elegba	Ojo	Lagos	27177.51969695...	89.99178707599...
9	Organic Dumpsite	Abolaji Hassan Street	Unofficial	GRID	Ilogbo- Elegba	Ojo	Lagos	27011.50802159...	85.47945576453...
10	Mixed Dumpsite	Adebimpe Street Dumpsite	Official	GRID	Orile-Ikosi	Kosofe	Lagos	59620.14225119...	149.0503556279...
11	Mixed Dumpsite	Adeniji Road Dumpsite	Unofficial	GRID	Olubori/Mosafejo	Kosofe	Lagos	47565.02482795...	141.9851487401...
12	Mixed Dumpsite	Adeniji Road Dumpsite 2	Unofficial	GRID	Olubori/Mosafejo	Kosofe	Lagos	36665.22196316...	121.8113686483...
13	Mixed Dumpsite	Adeniji Street Dumpsite	Unofficial	GRID	Agbelekale	Alimosho	Lagos	58546.07688677...	143.1444422659...
14	Mixed Dumpsite	Adenuga Dumpsite	Unofficial	GRID	Ajido	Badagry	Lagos	28796.40533500...	70.06424655719...
15	Mixed Dumpsite	Adeola S Olosunde Street	Unofficial	GRID	Ijegun	Alimosho	Lagos	24384.32542687...	84.37482846670...
16	Mixed Dumpsite	Adetola Lasisi Street Dumpsite	Unofficial	GRID	Orile-Ketu	Kosofe	Lagos	55036.84180217...	138.9819237428...
17	Toxic Dumpsite	Adife Dumping Site	Unofficial	GRID	Ojo Town	Ojo	Lagos	18536.89419049...	96.54632390880...
18	Mixed Dumpsite	Adoni House	Official	GRID	Apese/6 Extension	Eti Osa	Lagos	8081.656786203...	43.68463127677...
19	Organic Dumpsite	Aduwo Street	Unofficial	GRID	Ilogbo- Elegba	Ojo	Lagos	27105.68350994...	90.05210468420...
20	Mixed Dumpsite	Afolabi Junction Imude Road	Unofficial	GRID	Ilogbo- Elegba	Ojo	Lagos	26008.54564893...	80.27328903991...

Table 1: *Buffer table showing various dumpsites locations in lagos and the calculated population (ZS_sum) surrounding them.*

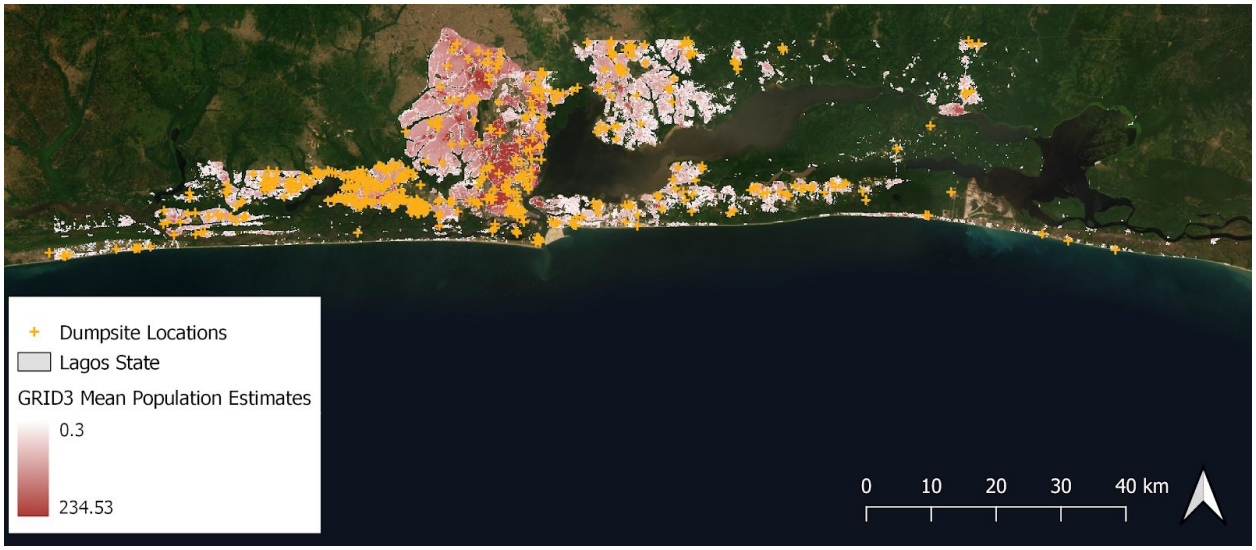

Figure 1: *Dumpsite locations in relation to the mean population estimates for Lagos.*

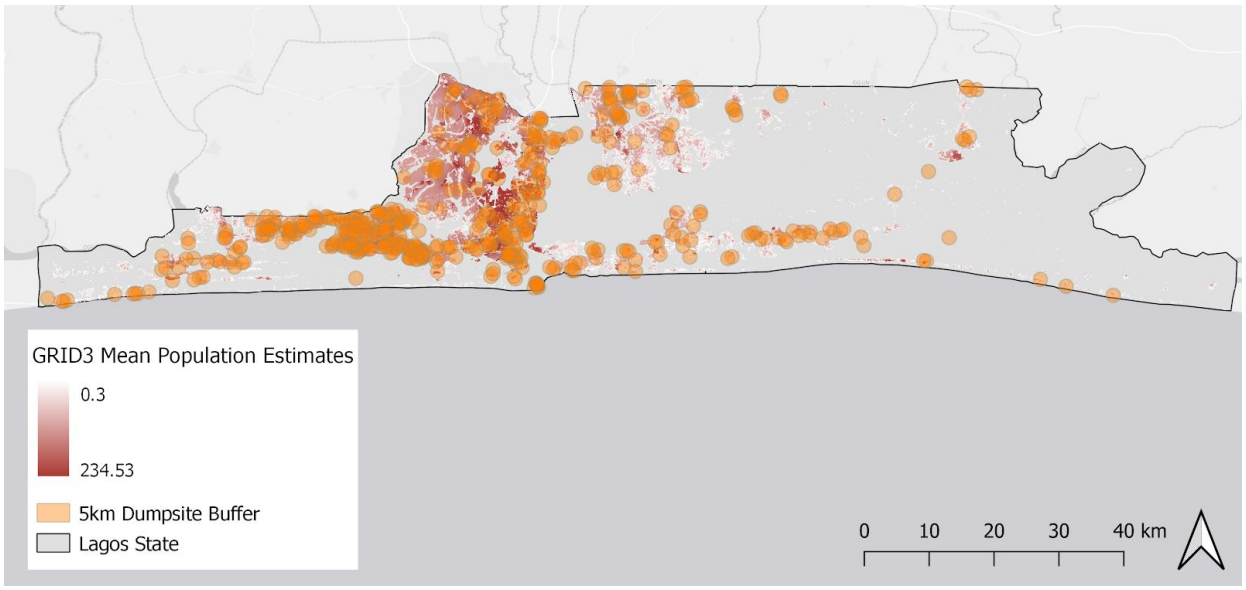

Figure 2: *5km buffer around each dumpsite location.*

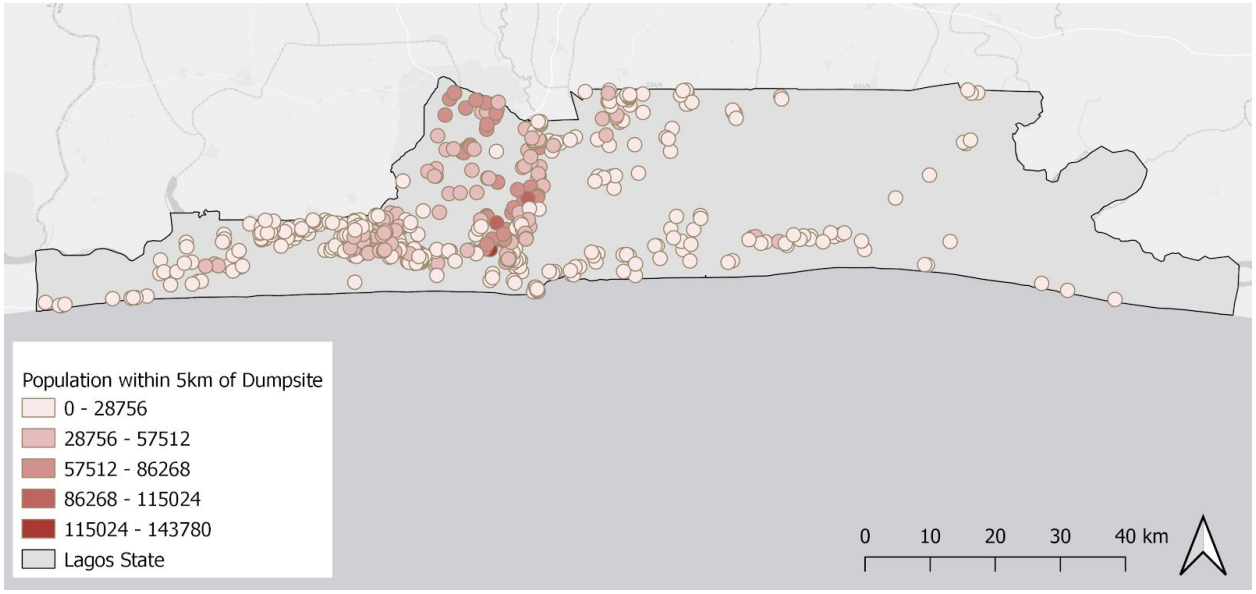

Figure 3: *Number of people within 5km of dumpsite location*

Risk

As associated with most analysis, there are always imminent risks which should be identified early enough to allow appropriate mitigation to be developed. We have also envisaged some potential risk associated with the implementation of reducing the impact of solid waste for communities and they include:

1. Impracticability; could be an easy concept on paper and in theory but can't really work in the real world because of various factors. Factors including: Existing structures or settlements on potential (harmless and easily accessible) landfills discovered, Cost of excavations might not really be worth it for the relevant government bodies.

2. Lack of relevant datasets.

3. The relevant government bodies may not be interested in adopting the outcome and for maximum impact, collaboration with a government body would be recommended. Possible relevant agencies: Ministry of Health, Ministry of Environment, NESREA - National Environmental Standards and Regulations Enforcement Agency, Waste Management Society of Nigeria, State and Local governments.

Future Developments

It would be possible to extend this proof of concept analysis into population proximity to dumpsite locations at a larger scale. This analysis could be repeated at a national level or for another state. As described at the beginning of the proposal, this preliminary analysis could feed into further decision-making on selecting locations for new dumpsites, or evaluating the risk to populations

located within close proximity. Such analysis should be developed in line with existing government policies, to ensure the outcomes can be directly applied to decision-making at a high level.

Acknowledgements

This concept note was developed by 'Yosola Adekanmbi Oluwaseun, with the support of Alina Game, Michael Harper and Wole Ademola Adewole from GRID3 / Flowminder. This work was part of the GRID3 Data Challenge, a competition organised by GRID3 to mentor and strengthen capacity in geospatial analytics of selected participants of Data Science Nigeria's 2019 Artificial Intelligence Bootcamp.

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