Samuel Cooper

Human Development - Data Science

5-20 October 2021

Disaster Response and Economic Instability in Haiti (2495 words)

"Development consists of the removal of various types of unfreedoms that leave people with little choice and little opportunity of exercising their reasoned agency" (5) Amartya Sen explains in his *Development as Freedom*. What people can achieve is influenced strongly by the economic opportunities available within a nation, and when these opportunities are taken away by external entities, Sen implies that freedom is a challenge to achieve. In the economically and socially burdened nation of Haiti, people are dealing with just that - an everyday fight to feed their families and to remove unfreedoms in the form of poverty, economic inequality, and lack of care for facilities to name a few.

United Nations Secretary-General Kofi Annan argued in 2005 that "A world of interdependence cannot be safe or just unless people everywhere are freed from want and fear and are able to live in dignity… the rights of the poor are as fundamental as those of the rich, and a broad understanding of them is as important to the security of the developed world as it is to that of the developing world" (6). Since the year 2010, citizens across Haiti have indeed been trapped in a world of fear. On January 12th 2010, a magnitude 7.0 earthquake struck the Republic of Haiti, with an epicenter located approximately 25 km south and west of the capital city of Port-au-Prince (7). Not only did it take the lives of 200,000 and cost almost $11 billion in reparations (close to 100% of the nation's gross domestic product), but the natural disaster resulted in the displacement and economic devastation of thousands (8).

But with time comes change, and with change comes new innovations and opportunities. Amartya Sen proclaims in his writing that unfreedom can come in all shapes and sizes, and each unfreedom is somehow interconnected. Yet more importantly, he also implies that opportunities are not given equally around the world (5). After the 2010 earthquake, it was evident that Haiti's access to current technology, data methods, and other resources was significantly lacking when compared to more sophisticated nations like the United States. Consequently, for a group of geoscientists located in France, the time had come to evoke change for their sister nation. When the next major earthquake came in 2021, a new innovation swept across the island - Raspberry Shake stations (3).

Raspberry Shake stations (RS stations), a network of inexpensive seismometers, installed in people's living rooms, gardens and workplaces across Haiti, have helped scientists in unraveling the inner workings of the 2021 earthquake (3). In a country whose official seismic-monitoring stations are sometimes offline because of limited resources, this community-seismology project has provided much-needed data. The seismometers are able to feed data into a system that displays the locations and magnitudes of Haitian earthquakes on a web-based portal in real time (3).

In relation to the inherent and complex nature of human development in Haiti, many people do not have access to proper technology in order to analyze complex situations like earthquakes and other natural disasters. Not only that, but as implied in previous articles,

education is lacking severely in Haiti. With nearly 100 RS stations established across the country, these locations have turned into small educational centers for Haitian people in addition to providing work opportunities (8). Additional opportunities like such are going to be how Haiti fiscally stimulates its economy while providing educational systems.

Geospatial datasets used in this study pertain to two different categories: vectors/attributes and social media data. In relation to vector/attributes, points, lines, dots, and other polygons were used to show the location of aftershock earthquakes, their magnitude, and overall direction. Social media data was also brought up for the limited amount of people in Haiti who have it: “However, in the age of social media and participatory science, complementary ways to produce reliable and actionable earthquake information through the involvement of citizens and/or communities are emerging that warrant further investigation” (3). Calais was also able to provide certain big data statistics from local social media posts. Geospatial data methods also include local surveying, maps, and cartography (3).

The results have shown at least 600 aftershocks from the August 14 earthquake so far, compared with roughly 10 in the same time period after the 2010 quake (8). Calais, a leader of the study, stated “We now have very strong information about not only where the [14 August] quake occurred, but also how wide the rupture was, in which direction the fault was dipping,”. Not only is this essential to understanding why the quake occurred, but it is also essential so they could know where the quake occurred. This type of technology during the 2021 quake allowed for more efficient, effective, and rapid disaster response for those in Haiti, and it is argued that thousands of lives were saved (3). In a world constantly changing from human impact and development, having this technology to help respond more effectively to disasters for undeveloped nations is going to be key.

In addition to physically measuring earthquakes in Haiti, data scientists have also been able to measure population dispersion and mobility through innovative techniques: phone usage. Using mobile operator geospatial data and the data science method of clustering, Flowminder, in collaboration with Digicel Haiti, have been able to track population density and mobility after the 2021 earthquake in Haiti (1). Through aggregated sampling and calculating the number of subscribers who made or received a call per cell tower cluster, data scientists essentially were able to track citizens and make logical decisions in order to direct response efforts (1).

Two specific studies in relation to phone clustering are relevant, the first focusing on immediate details, and the second delving into more long-term realizations. Results from the first study show a clear trend: geographical illustrations show the redistribution of Digicel Haiti subscribers from the centre of Les Cayes and Camp Perrin to other locations across the Nation (1). As the article conveys, these results could be caused partially by residents leaving, but also partly by visitors not coming into the city center as much as before (1). In a fragile nation like Haiti, a sharp decrease in citizen influx, tourism, and economic flow can cause serious long-term damage.

Findings from the first study presented the following to data scientists: Nearly half of the relocated people (45,000 persons) were widely spread across 62 communal sections and 26 communes out of 43, in estimated numbers ranging from 100 to 2,000 persons per communal section (1). In response to this sample clustering data, statistical conclusions were able to be made in relation to the true proportion of people in these given areas, in order to direct response efforts to specific locations (1).

Cell phones and other basic electronic devices like radios helped direct response efforts in other ways as well throughout Haiti. Two days after the quake in 2021, Thomson Reuters

Foundation's AlertNet humanitarian news service arrived at Port-au-Prince's international airport to set up the first-ever Emergency Information Service (EIS), offering Haitians free, practical SMS messages and charging stations to help them minimize the disaster's impact (9). Just a few days after the earthquake, EIS was able to direct injured Haitians via text message to one of the few hospitals able to treat patients (9).

Likewise, the service also helped search-and-rescue teams to find people trapped in the rubble. In one specific case, a man trapped for five days in a collapsed building in downtown Port-au-Prince sent a text message, which the EIS team, working through the night with experts around the world, translated into GPS coordinates. A search-and-rescue team was dispatched and saved his life (9). This example, one of hundreds to thousands, highlights the prime importance of using geospatial data in response to natural disasters: saving lives. If a response team does not know who they are looking for or where they are looking, how do they even begin conducting a disaster response? GPS data via SMS messaging has been and will continue to be crucial for developing nations like Haiti when disaster strikes.

In relation to the second article, the peer reviewed journal begins by addressing one of the main problems at hand in Haiti - rapid urbanisation with the absence of economic growth has led to increasing socioeconomic challenges (4). After the major earthquakes in 2010 and 2021, population displacement occurred rapidly across the country. With almost 6 million Haitians living in urban areas, as the article explained, cities now host over 0.5 million more inhabitants than rural areas (4). The rapid, unplanned urbanisation in Haiti has generated a series of urban mobility challenges which have contributed to job market fragmentation and a decrease in quality of life (4).

Data on population and job distributions, and on home-work commuting patterns in major urban centres of Haiti is scarce, with the last census not being taken until 2003 (4). The article shows how scientists have taken advantage of nationwide de-identified Call Detail Records (CDR) from the main mobile operator to investigate night and daytime populations densities and commuting patterns (4). Geospatial datasets used in this study include cell phone data from cell towers, calls routed by satellite, and other census data based on GPS location coordinates. In relation to methods, this study uses a variety ranging from clustering algorithms, to k-means, trend lines standard deviation (descriptive statistics), and Gaussian mixture clustering methods (4).

Plagued by many different events with a weak government that has failed to help citizens, the study shows clear results that the people of Haiti have moved towards cities with increased opportunities to improve standard of living (4). This also directly relates to Geoffrey West's argument about cities in his book *The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and Companies*: the positives of cities (opportunities and growth) outweigh the negatives (crime, disease, density) for people (10). Cities foster new beginnings and better job opportunities, as thousands of Haitian people believed after the devastating earthquake. The data scientists, using satellite imagery, saw the center of Port-au-Prince searching up to 60,000 people per square kilometer during the evening, a contrast of at least 5,000-10,000 people from before (4). Another neighborhood amongst many others, Canaan, saw densities of between 10,000 and 15,000 people during the sampled time period, a significantly larger quantity prior than the earthquakes (4). Through paragraphs of carefully sampled and analyzed data, the trend of Haitian cities is clear: when tragedy strikes and the economic situation worsens, people are forced to flee to cities where job opportunities are more likely.

Yet for this rudimentary nation centered on the Caribbean plate, earthquakes have not been the only devastating concern for Haitian people. On October 4th 2016, Matthew, a category four hurricane, made landfall over southwest Haiti, resulting in catastrophic damage to the Grande Anse and Sud regions (2). The storm cost almost two billion dollars in damage, took the lives of 500 people in Haiti, and displaced many thousands of people (2). Daniel Power, receiving his PhD in Complex Systems Science from the University of Southampton amongst other authors, took action after this hurricane and developed a case study relating to human development. One of the biggest ideas relating to harmful events that came up in the study was the idea of the cholera epidemic - an already devastating swing of disease that had taken the lives of many Haitian people (2). With Hurricane Matthew destroying water supply infrastructure, sanitation systems, and established cholera treatment centers, the already fragile healthcare system in Haiti seemed to be at the brink of collapse (2).

The cholera epidemic of Haiti dates back six years even before Matthew hit Haiti. In 2010, the Haitian Ministry of Public Health and Population (MSPP) was notified of increased cases of acute watery diarrhea resulting in death among adults in Artibonite Department (11). Due to improper sanitation and odious drinking water from prior floods, many people were getting sick and a group from the CDC began investigating the Artibonite river region with a case study (11).

What the study found was shocking: a large proportion of people were getting ill from drinking sugarcane juice, in relative equal proportion to that of the contaminated water. What people were not realizing is that they were drinking sugarcane juice with ice, and this ice contained the bacteria from cholera that were indirectly killing citizens (11). But the more important conclusion from the study that one should realize is as follows: the cholera epidemic should galvanize both governmental and nongovernmental organizations to address Haitians' need for safe water and sanitation (2). When individuals don't have access to proper drinking water and have an increased risk of death due to something so preventable, their lives are impacted in a variety of other ways. Those who were affected and becoming ill inadvertently lost their jobs, thus putting themselves and their families in jeopardy. Likewise, thousands of Haitian people were and continue to be impacted by the cholera epidemic (11), and this has further contributed to economic disparity in Haiti. Six years later, this problem continues to be evident and impacts Haitian citizens everyday.

The presence of cholera increased the need to identify human displacement, with a "particular emphasis on understanding where people had come from, as this information was used to inform relief management efforts on containing the disease among a highly vulnerable population" (11). With a high displacement among citizens, inadequate access to hospitals, a lack of essential technology, and the ability for most to only travel by foot, reporting this information would become a major challenge (11). Flowminder, a nonprofit organization, was able to help by corralling Haiti Digicel's mobile data, information that would have been difficult and costly to obtain through other means, particularly post-disaster. Flowminder was able to use FlowKit, a suite of software tools that help humanitarian and development organizations access and analyze mobile data from a geographical standpoint (11). In terms of data science methods, the report included graphs, clustering of individuals, and Bayesian statistics (11).

Results from this study clearly indicate the following idea: sustainable development goals should be focused on initiating efforts that can improve healthcare in Haiti, impactful sanitation systems, storm-response education, and mandating evacuation. Results show that more than 1.4 million people were affected by the hurricane and displaced to unknown locations, with the

largest quantities of between 15,000 and 35,000 people moving to Port-au-prince and Jeremie sectors (11). Local government did not mandate or even impose any evacuation route system in response to the hurricane, something that would have decreased chaos drastically (11). The article also put an emphasis on a specific dimension of human development: education and health, focusing on the scientific question *how did the people of Haiti respond in the aftermath of Matthew in relation to movement and health? How can data scientists cluster individuals into specific movement groups based on cell tower data?*

Works Cited

(1) 1st ed., Flowminder Foundation, 2021, pp. 1–5, *Population Movements Estimated with Mobile Operator Data from Digicel Haiti: Report from 20 August.* Accessed 21 Sep. 2021.

(2) Power, Daniel, et al. Digital Impact Alliance (DIAL), 2019, pp. 4–12, *FlowKit: Unlocking the Power of Mobile Data for Humanitarian and Development Purposes.* Accessed 22 Sep. 2021.

(3) Calais E, Boisson D, Symithe S, Prépetit C, Pierre B, Ulyse S, Hurbon L, Gilles A, Théodat J-M, Monfret T, Deschamps A, Courboulex F, Chèze J, Peix F, Bertrand E, Ampuero J-P, Mercier de Lépinay B, Balestra J, Berenguer J-L, Bossu R, Fallou L and Clouard V (2020) A Socio-Seismology Experiment in Haiti. *Front. Earth Sci.* 8:542654. doi: 10.3389/feart.2020.542654 Accessed 27 Sep. 2021.

(4) Zagattia, Guilherme Augusto, and Miguel Gonzaleza. "A Trip to Work: Estimation of Origin and Destination of Commuting Patterns in the Main Metropolitan Regions of Haiti Using CDR." *Development Engineering*, Edited by Ashok Gadgil, vol. 3, no. 2352-7285, 2018, pp. 133–165., https://www.sciencedirect.com/science/article/pii/S2352728517300866?via%3Dihub. Accessed 1 Oct. 2021.

(5) Sen, Amartya, 1933-. Development as Freedom. New York : Anchor Books, 2000.

(6) Annan, K. 2005. *"In Larger Freedom":* Decision Time at the UN. Foreign Affairs. Available at: http://www.unis.unvienna.org/pdf/freedom_annan.pdf. Accessed 6 October 2021

(7) Eberhard, M. O., Baldridge, S., Marshall, J., Mooney, W., and Rix, G. J., 2010. The MW 7.0 Haiti earthquake of January 12, 2010: USGS=EERI Advance Reconnaissance Team Report, USGS Open File Report 2010–1048, U.S. Geological Survey, Reston, VA, 58 pp. Accessed 1 October 2021

(8) E. Calais, D. Boisson. "Monitoring Haiti's Quakes with Raspberry Shake." *Eos*, AUG Journals, 17 May 2019,https://eos.org/science-updates/monitoring-haitis-quakes-with-raspberry-shake. Accessed 6 October 2021

(9) Person. "Cell Phones and Radios Help Save Lives after Haiti Earthquake." *Reuters*, Thomson Reuters, 25 Jan. 2010,https://www.reuters.com/article/us-haiti-telecoms/cell-phones-and-radios-help-save-lives-after-haiti-earthquake-idUSTRE60O07M20100125. Accessed 10 October 2021

(10) West, Geoffrey B. *Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and Companies*. Penguin Press, 2018.

(11) O'Connor, Katherine. Risk Factors Early in the 2010 Cholera Epidemic, Haiti. Centers for Disease Control and Prevention, 2011, www.cdc.gov/eid. Accessed 19 October 2021 Emerging Infectious Diseases.