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Human Development - Data Science

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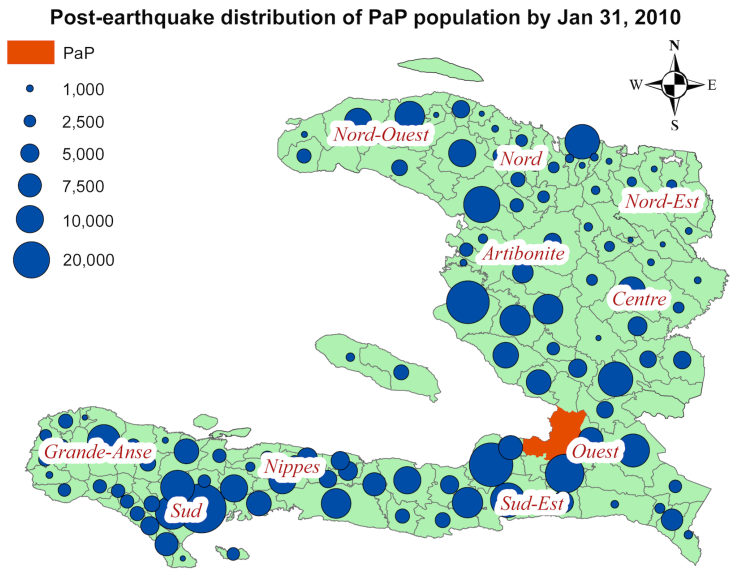
Disaster Response and Economic Instability Methods (1565 Words)

"Development consists of the removal of various types of unfreedoms that leave people with little choice and little opportunity of exercising their reasoned agency" (1) 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. To make matters worse, the nation has been plagued with a variety of natural disasters over the last 11 years, with the earthquake of 2010 acting as the cascade. 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 (2). 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 (3).

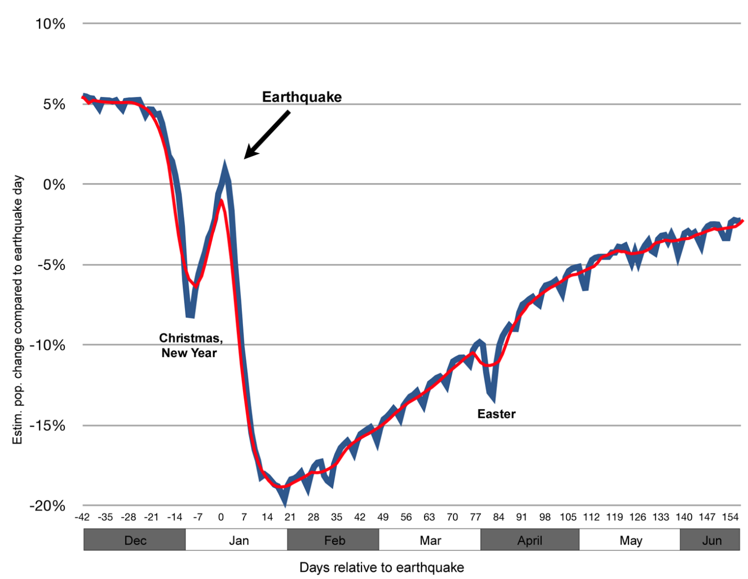
As a result of such negative externalities in the nation of Haiti, different trends relating displacement, disaster response, urbanization and economic instability have been analyzed, proving a variety of statistical results to the following research question: *When disaster strikes in a burdened nation, how do those impacted respond and how effectively are response efforts implemented?* In other words, where do people go? What are these people trying to do? What are their intentions, and how are they aided by local organizations and response efforts? Through aggregated clustering of mobile data and the use of satellite imagery and maps, two different yet impactful data science methods, study directors and data scientists have been able to provide meaningful answers to these complex questions. With the clustering technique, scientists have been able to sample different cell tower locations and track citizens through the use of their mobile device. With satellite imagery and maps in aid of statistical tools, density and depth with respect to the number of people in a given area have also been used.

In relation to cellular clustering techniques throughout the nation of Haiti, a variety of studies and peer-reviewed journals have been generated. 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 (4). 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 (4).

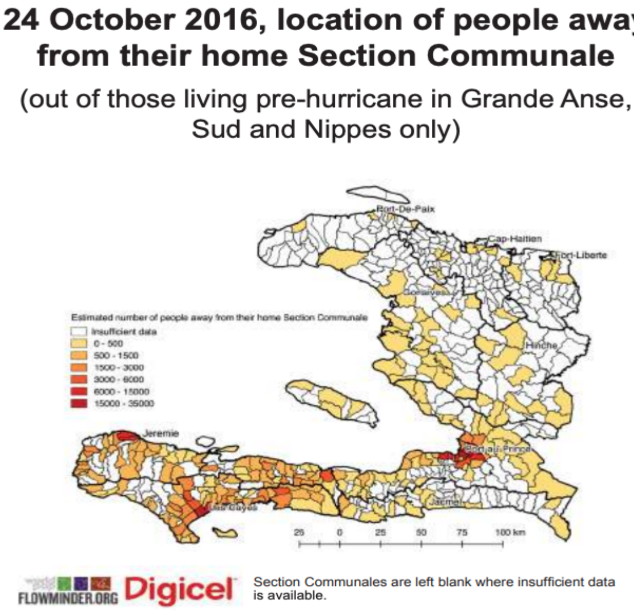
Two specific studies in relation to phone clustering are relevant, the first focusing on immediate details, and the second delving into more long-term realizations. Methods from the first study delve into SIM card usage and phone location via cell tower. Geographic positions of SIM cards were determined by the location of the mobile phone tower through which each SIM card connects when calling (4). Scientists followed daily positions of SIM cards 42 days before the earthquake and 158 days after. To exclude unactivated SIM cards, the data scientists included only the 1.9 million SIM cards that made at least one call both pre-earthquake and during the last month of study (5). In Port-au-Prince, there were 3.2 people per given SIM card. The ratio was used to extrapolate from the number of moving SIM cards to the number of moving persons, and an estimated 630,000 people (197,484 Digicel SIM cards), present in Port-au-Prince on the day of the earthquake, had left 19 days post-earthquake (5). Estimated net outflow of people (outflow minus inflow) corresponded to 20% of the Port-au-Prince pre-earthquake population (4).



(Fig. 1)



(Fig. 2)



(Fig. 3)

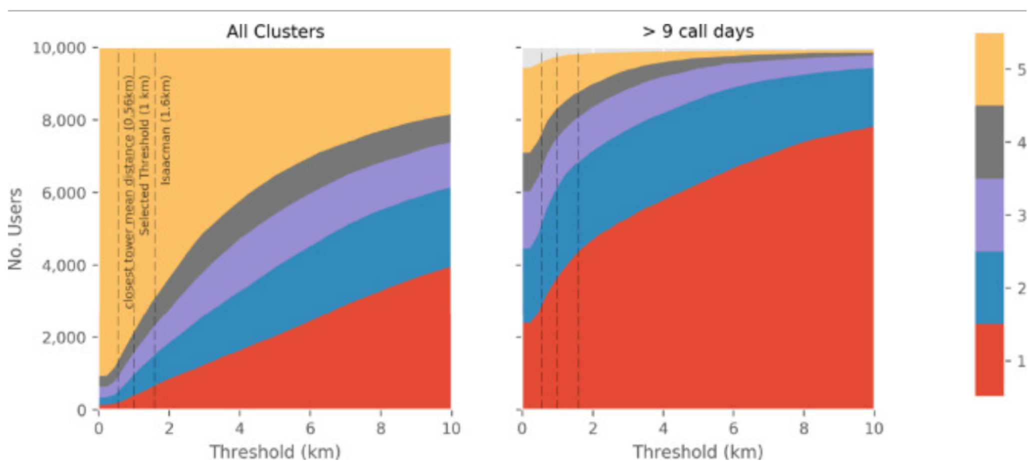
Results from the first study show a clear trend: geographical illustrations show the redistribution of Digicel Haiti subscribers from the centre of Les Cayes and Camp Perrin to other locations across the Nation (4). As the article conveys, these results could be caused partially by residents leaving, but also partly by visitors not coming into the city center as much as before (4). 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 (4). 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 (4).

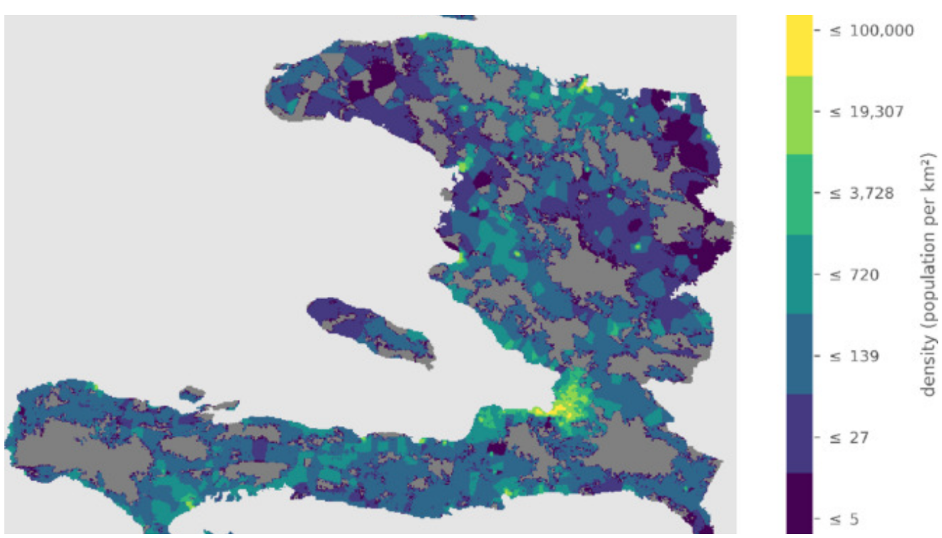
In terms of a research gap reflecting a limitation and need for improvement within this mobile data clustering method, the study explains that Digicel Haiti, with 2.2 million subscribers and a network that covers 90% of the inhabited areas, was the experimental group used (4). There are two main reasons that this strategy could have resulted in potentially skewed data and certain misleading conclusions. Firstly, Digicel Haiti only covers 90% of inhabited areas in the nation, leaving the other 10% completely unrepresented within this study. Secondly, and most importantly, the teqnicnique of using mobile data does not even take into consideration those without electronic devices. Haiti is a nation plagued by economic disparity and instability, and owning a phone for many people is extremely costly and not very feasible. In essence, this given technique from the study has failed to not only represent the 10% who do not use Digicel Haiti, but it also fails to consider a large proportion of people who do not have phones, potentially resulting in misrepresented results.

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 (9). 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 (9). 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 (9).

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 (9). 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 (9). Geospatial datasets used in this study include cell phone calls routed by satellite, but most importantly, satellite imagery to present population density. 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 (9).



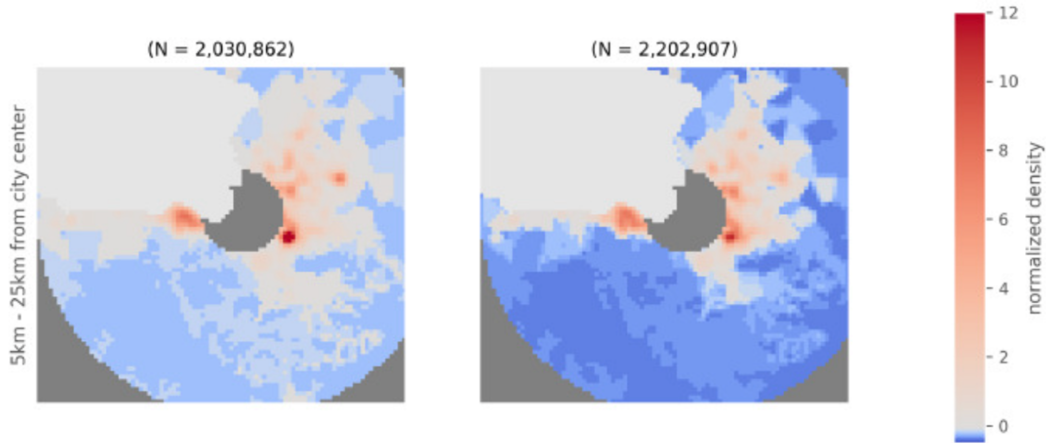
(Fig. 4)



(Fig. 5)

While field information is still important, collecting data, as applied to this study, can be very expensive and may only be possible assuming high risks, especially in fragile and conflict-affected areas like Haiti. Furthermore, contextual information in such areas becomes outdated very fast, and rudimentary nations like Haiti can often have outdated census information, as seen.

As conveyed in this study, with k-clustering, a satellite imagery technique, each pixel can be understood as a three-dimensional numerical vector. That is, each pixel is defined by its values for the red, green and blue spectral bands (12). The pixels then form a collection of vectors. The *k-means* algorithm is then conducted, distributing all those pixels to *k* different clusters, in our case based only on density (12). Such optimization algorithms work by assigning each pixel to the cluster whose vector is closest to the pixel, to then re-compute the new mean of each resulting cluster after the new pixel assignments, and to repeat these two same actions again and again until the distribution of pixels in clusters is stable (12). In our case at hands, for example, the pixels represent population distribution in dense areas, showing, for example, people who enter and leave for work (an example is in figure 6 below).



(Fig. 6)

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 (9). 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 (9). 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.

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