Using passive anonymous mobile positioning data & aggregation analytics to enhance tool-sets for flood relief agencies

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Abstract*— after a natural flood disaster, relief agencies need to know where influenced individuals are located, what things are required, and who is protected. This data is incredibly tough and often difficult to get through traditional data gathering strategies [1] in an opportune way. This study can give bits of knowledge in near-real time to help relief agencies to facilitate their work and fill pivotal holes in information amid disasters. Utilizing mobile positioning data and aggregation data analytics we can design a better solution for relief agencies with the goal that they could plan the activities better. This study explains about the data analytics of Location, displacement and population density of the affected area with comparison to its historical data of few weeks that can predict good quality results and tools to handle the response phase of flood disaster. This investigation clarifies the advancement of Cellular Network Coverage, Power, Displacement, and Safety check diagramsbased upon data aggregation analytics on Mobile positioning data of the cellular phone we carry. This study encourages agencies to address the critical gap in information they frequently face when reacting to cataclysmic events. Study graphs give data about where populaces are found, how they are travelling, and where they are feeling themselves safe amid a cataclysmic event. We can impart these accumulated bits of knowledge to relief agencies so that they have the data they need to help communities recuperate and revamp if debacle strikes. Likewise this will also help to assist them in satisfying the necessities of migrating, food, shelter, electricity, water and other fundamental needs of the people in question.

Index Terms— *MPD, data-aggregation, flood rescue, Mobile computing, Global Positioning System, Cellular networks*

I. INTRODUCTION

In the past decade much research has focused on Mobile location data either through any mobile app or mobile GPS data with a condition location 'on'. In realty, at the time of disaster, our high expectations from the victims that they will use their mobile with location 'on' continuously and daily in the response seems unpractical. This study proposes passive mobile positioning data [2] managed by mobile network operators as a base to develop crisis tools. It remains unclear that why this MPD is still in the hands of very few government agencies. Answer can be the data privacy policy of any country and security is one of the reasons to hide this from public. This study proposes here to mine the data without hitting the security, safety and privacy policy. This study explains the use this MPD in various GIS related platform to solve many real world problems.Amid flood debacle, where here has a fiasco damaged cellular network? Where can individuals get to a cellular system to connect with their loved ones? Where are individuals ready to charge their gadgets in a fiasco influenced region? What does this infer about power accessibility? What numbers of individuals have been dislodged from their home city after a catastrophe? Which towns are these individuals dislodged from? Which towns are dislodged individuals moving to?

II. LITERATURE SURVEY

To move more nearer to the issues of people and relief agencies at the time of any disaster, we have taken few case studies mentined below to analyze different aspects during disaster using one popular mobile application with GPS location ‘on’.

A. For Cellular(Mobile) Network Coverage Survey

Contextual analysis: Volcanic Eruption in Guatemala

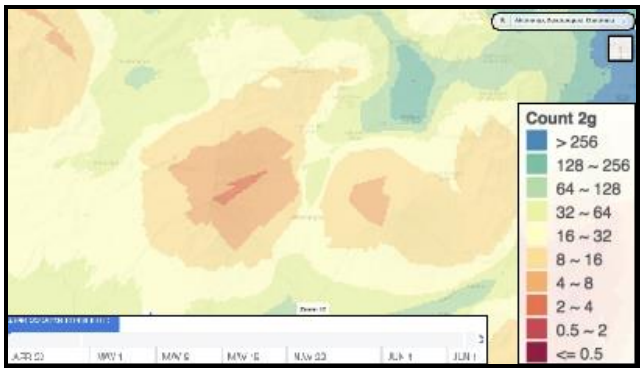

Fig. 1.2G network before Volcanic Eruption - Guatemala

Heat Map [3], which demonstrates the 2G network map in Alotenango, Guatemala on April 22, 2018 before the volcanic emission as shown in Fig 1 above. The perception below shows 2G network diagram on June 10, 2018, 4 days after the volcanic emission as shown in Fig 2 below. In light of the sharp increments in red and orange regions, also full blank spots on the map, we can see a sharp drop in network use in the territories encompassing the site of the ejection.

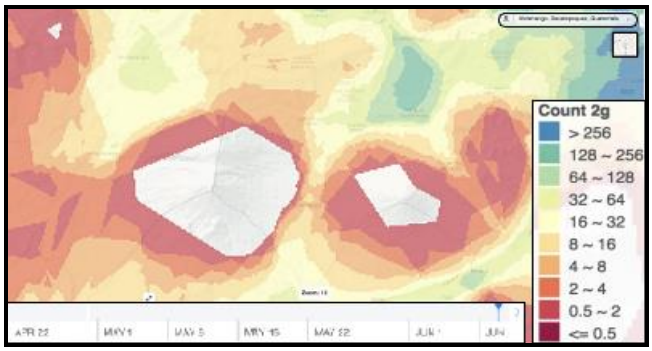

Fig. 2.2G network after Volcanic Eruption – Guatemala

B. Battery/Power Charging Survey in Affected areas

Contextual analysis: Storms in Ranchi, India

The figure beneath shows changes in number of mobile phones backed with power, communicated as the baseline average, in zones close to Ranchi, India on May 28, 2018 as shown in Fig 3 below, which experienced power blackouts in the wake of lightning and thunder storms. While control accessibility was not influenced in the downtown area of Ranchi where the zone is as yet light blue, there was a sharp decline in the quantity of mobile phones interfacing with power in territories outside the city, featured in red. [5]

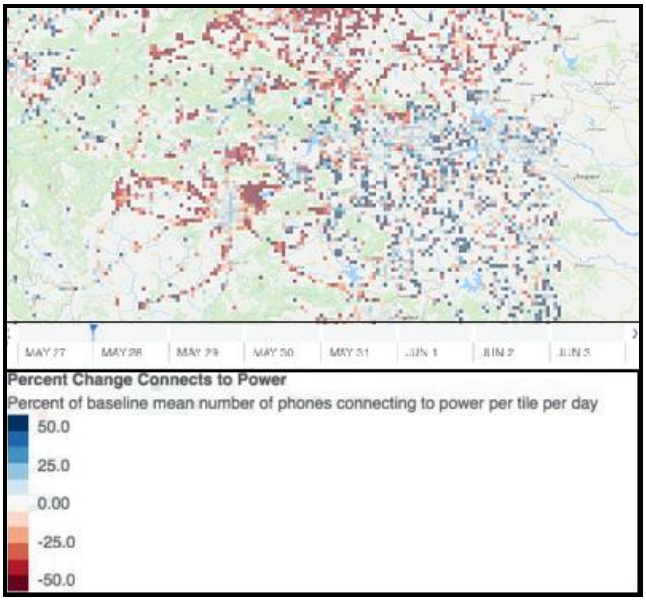

Fig. 3.Mobiles communicated in zones close to Ranchi, India (May 28, 2018)

C. For polulation Displacement Survey:

Contextual analysis: Wildfires in Northern California

In October 2017, obliterating rapidly spreading fires devastated an expected 8,900 structures in the Napa Valley area, constraining 100,000 individuals to move, huge numbers of who remained uprooted from their homes well after the flames were smothered. The figure underneath demonstrates the net difference in populace amid this time, revealing the absolute change in the quantity of individuals in every city in the week of December 4, 2017, around 2 months after the flames began, contrasted with the week prior to the flames began as shown in Fig 4 below.

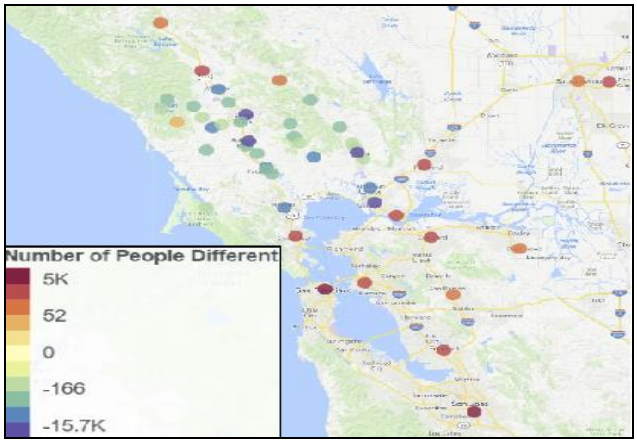

Fig. 4.Populace representation (Wildfires- Northern California - 2017)

The points in purple, blue, and green show urban areas with a decline in individuals, while the orange and red points show urban communities with an expansion in populace. From this representation, we can see that about the majority of the urban areas in the Napa Region demonstrate some diminishing in populace after the flames, including Santa Rosa, Rohnert Park, Napa, and Vallejo [7] . We can likewise observe the urban communities where uprooted individuals went in huge numbers, including real urban areas outside the risk zone, for example, San Francisco and San Jose.

D. For Safety Check Survey:

Contextual analysis: Safety Check

Fig. 5.Fort McMurray Safety Check Indicators

Within 24 hours of actuating Safety Check, we see that there are far less individuals than expected in the town of Fort McMurray. Regions that are shading coded red reflect much lower quantities of Mobile people there contrasted with a similar time the prior week as shown in Fig 5 above. This bodes well since these areas are influenced by the rapidly spreading fires and have in this way been evacuated.

III. RESEARCH DESIGN AND METHODOLOGY

Study is being done by taking the report 'Feasibility Study on the Use of Mobile Positioning Data for Tourism Statistics' [4] [6] as a base of the research and then refining the same technology and processing of data to do various spatial analytics specific to flood disaster. The procedure contains the accompanying areas: the extra readiness of

occasion information, frame creation, data aggregation and estimation. The base data filtered and arranged by MNOs depends on system events that determine a particular customer's presence in reality. Extra readiness may incorporate geological referencing, the removal of non-human operated cell phones, checking the time and territory coverage of the data, managing missing qualities, and so forth as shown in Fig 6 below.

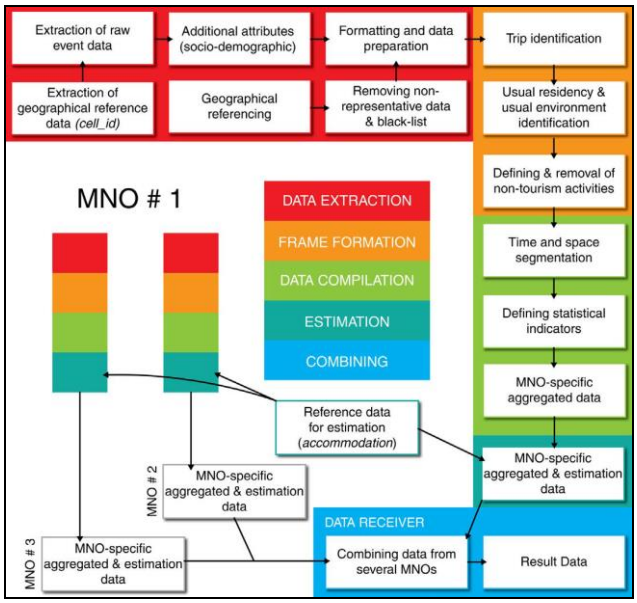

Fig. 6.Mobile positioning data processing steps

At the point when individuals utilizes a cell phone , their x and y coordinates are received at regular intervals and gets recorded as passive MPD data by MNO's [5]. This Location data is utilized in various ways, such as delivering a feature or content that is most important to individuals. For instance, it enables us to send notifications to individuals' news feeds in focused pursuit regions after a kid has been stole, or Safety Check warnings to those in areas influenced by catastrophic events.Same geolocation information, when amassed and de-recognized, gives important data to help relief agencies after a catastrophic event. Conglomeration not only helps to maintain security, yet additionally makes the information increasingly usable and interpretable to relief agencies by isolating disturbance from clamor, and in this way diminishing the intermediate compilation steps required to move from data to insights for action.

The debacle maps datasets are accumulated crosswise over time in the accompanying ways:

- Temporal accumulation: While data is required over time frequently amid a debacle. Consequently, we share information at consistent time lapse (e.g., Every 24 hours, every six hours, and every hour).
- Spatial conglomeration: We totaled geo-localized spots to 360,000 square meter tiles or nearby administrative limits.
- Spatial smoothing: Once we have determined every metric (e.g., the count of individuals in administrative or pixel unit x amid timespan y), spatial smoothing is build. For each spatial area, we process a weighted average of the value in the tile itself with the values in adjacent square tiles; tiles that are nearer have a greater commitment to the final outcome . This neighborhood averaging results in a map with a smoother, more clear signal, lessening commotion because of irregular variation while safeguarding the key signal and further securing privacy.

IV. SYSTEM DEVELOPMENT AND RESULTS

Utilizing the information and total procedures depicted above, we can create three exceptional datasets:

• Population Diagram: Metrics showing the density of the MPD populace in each square tile.

• Movement Diagram: Metrics identified with populace displacement between tile sets.

• Safety Check Diagram: Metrics showing the density of Safety Check registration versus all solicitations for each tile.

A. Polulation Density Diagrams

By totaling geolocation information, we can demonstrate a smoothed portrayal of what number of individuals with area administrations empowered is utilizing Cell telephone in each regulatory district or guide network for each timespan. One of the impediments of giving counts is that it isn't promptly clear which esteems speak to significant deviations from normal. To help give this specific situation, we likewise incorporate baseline counts – an estimation of what numbers of individuals (estimated from a similar populace) are in each managerial zone averaged over the past three weeks at the same time. By coordinating with location and time, we can be progressively sure that any difference we watch are because of the fiasco occasion and hence are imperative to concentrate on. We likewise give extra insights to show whether the watched changes in density are factually important and meaningful.

The information is organized as pursues where every measurement is determined per unique area as shown in Table1 below:

Table 1. Z_score Computational Matrix

CRISIS_NAME	TIME_WINDOW	AREA_ID	N_BASELINE	DENSITY_BASELINE	N_CRISIS	DENSITY_CRISIS	N_DIFF	PERCENT_CHANGE	Z_SCORE
"Flood in Country X"	t1	a1	x1	x1 / total n_baseline at t1	y1	y1 / total n_crisis at t1	y1 - x1	100 * (y1 - x1) / x1	(y1 - x1) / (Var (y1 - x1) ^ 0.5)
"Flood in Country X"	t2	a2	x2	x2 / total n_baseline at t2	y2	y2 / total n_crisis at t2	y2 - x2	101 * (y2 - x2) / x2	(y2 - x2) / (Var (y2 - x2) ^ 0.5)
"Flood in Country X"	t3	a3	x3	x3 / total n_baseline at t3	y3	y3 / total n_crisis at t3	y3 - x3	102 * (y3 - x3) / x3	(y3 - x3) / (Var (y3 - x3) ^ 0.5)
"Flood in Country X"	t4	a4	x4	x4 / total n_baseline at t4	y4	y4 / total n_crisis at t4	y4 - x4	103 * (y4 - x4) / x4	(y4 - x4) / (Var (y4 - x4) ^ 0.5)
"Flood in Country X"	t5	a5	x5	x5 / total n_baseline at t5	y5	y5 / total n_crisis at t5	y5 - x5	104 * (y5 - x5) / x5	(y5 - x5) / (Var (y5 - x5) ^ 0.5)

Where

- crisis_name: The name of the disaster.
- time_window: The hour(s) amid which the information are recorded.
- area_id: The tile name. In the raster structure, this speaks to a given raster pixel on the map which can be spatially totaled to be interoperable with other informational sets. In the managerial structure, the area_id speaks to the authoritative limit name of a zone that can be united with other regulatory datasets (for example census data).
- n_baseline, density_baseline: The average number of individuals in a similar zone amid a similar time window however found the averaged over the past 3 weeks. This evaluations what number of individuals, we are hoping to be in every region amid the predetermined time.
- n_crisis, density_crisis: The count of individuals present in the tile amid the timeframe t.
- n_diff: The contrast between the populace during emergency and the populace during the baseline.
- percent_change: The percentage difference between the populace during the emergency and the populace amid the baseline.
- z_score: The count of standard deviations by which the emergency populace varies from the baseline.

Result output as shown in Fig 7 below:

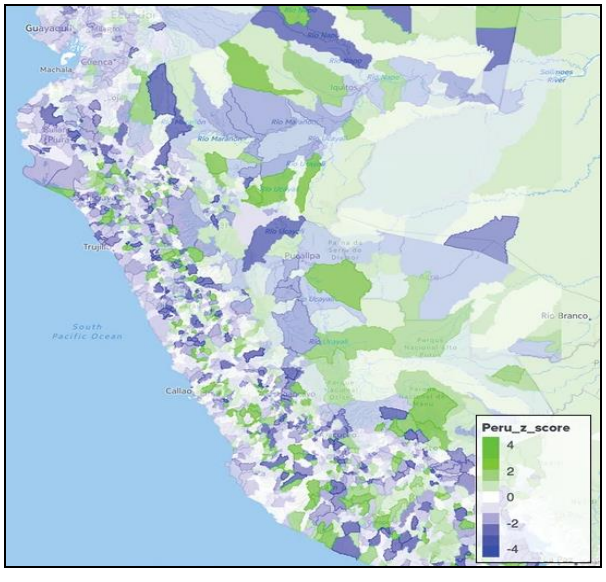

Fig. 7.Populace Density compared with historic data

B. Mobile Network Coverage diagrams

Mobile network coverage is critical amid times of any disaster, as floods, sea hurricanes and tornadoes can harm cell towers and upset critical network availability framework. Influenced populaces should most likely speak with loved ones, and relief agencies should almost certainly speak with influenced populaces and staff. This Cellular Network Coverage diagrams can give information on where mobile network is accessible for populaces influenced by catastrophic events.

• Challenges: What is the status of disturbed mobile network? Where can individuals move to get to a mobile network to associate with their family and companions?

• Data and Methodology: Most of the general population is having Cell phones today. We can gather the information on, which towers are giving the connections and where the cell phone is located. This Mobile location information does not interface the gadget to an individual's name or some other distinguishing data. For every cell tower in the calamity influenced locale, we estimate the span of the inclusion territory dependent on the locations of gadgets that have associated with it. We would then be able to contrast this estimate and a historic data collection of a quarter of a year of authentic information to distinguish changes in the inclusion territory brought up by the debacle.

• Metrics: The Mobile network diagram is displayed as a raster matrix. For every cell in the matrix, we give:

• An estimate of the quantity of cell towers giving inclusion.

• A z-score speaking to the difference in standard deviations between the count of associations initializing from the grid cell amid the baseline time frame contrasted with the count of associations amid the emergency.

C. Battery Charging Diagrams

Access to power empowers basic exercises like warming or cooling one's home, lighting a room, or charging a wireless. At the point when control foundation is down, relief agencies need to realize where individuals are without power. We can make diagrams that estimate electricity accessibility by counting the number of mobiles interfacing with or disengaging from power. On the off chance that the volume of cell-phones charging after a calamity drops fundamentally contrasted with ordinary dimensions, we

can attest that power may not be accessible around there.

• Challenges: Where are individuals able to charge their gadgets in a calamity influenced zone? What does this infer about power accessibility?

• Data and Methodology: Combining data from location networks and the Android base, we total and smooth data on the count of cell-phones interfacing or disengaging from power. So as to set up baseline measures, we gauge the average number of cell-phones over the calamity affected area interfacing with power before the catastrophe. We at that point gauge changes in the count of cell phones interfacing with power in the region amid the debacle contrasted with the baseline.

• Metrics: Similar to the mobile network inclusion diagram, the battery charging diagram is introduced as a raster grid. For every cell in the framework, we give. The totaled number of cell-phones interfacing with and detaching from power previously, amid, and after the catastrophe. A z-score speaking to the change in standard deviations between the quantity of battery charges amid the catastrophe and the quantity of charges before the debacle started.

• Data Considerations: notwithstanding the information contemplations raised above for the Network Coverage Diagrams, for Battery Charging Maps, we can't recognize every unique kind of intensity sources. We do sift through occurrences where individuals might charge their telephones in vehicles, so as to all the more intently proxy the accessibility of electricity facilities amid fiascos.

D. Displacement Diagrams:

This dataset contains data about the count of individuals moving between tile combines over a given timeframe. We measure this amid benchmark (displacement between tile sets averaged over the three weeks before the fiasco) also, so we can see what number of more or less individuals are moving amid the calamity time frame contrasted with normal. This encourages us recognize calamity related displacements from individuals' typical relocation designs.

This information resemble as shown in Table 2 below:

CRISIS_NAME	TIME_WINDOW	AREA_ID_START	AREA_ID_END	N_PEOPLE_BASELINE	N_PEOPLE_CRISIS	N_DIFF	PERCENT_CHANGE
"Flood in Country X"	t1	s1	e1	b1	c1	c1-b1	100 * (c1 - b1) / b1
"Flood in Country X"	t2	s2	e2	b2	c2	c2-b2	101 * (c2 - b2) / b2
"Flood in Country X"	t3	s3	e3	b3	c3	c3-b3	102 * (c3 - b3) / b3
"Flood in Country X"	t3	s3	e3	b3	c3	c3-b3	102 * (c3 - b3) / b3
"Flood in Country X"	t3	s3	e3	b3	c3	c3-b3	102 * (c3 - b3) / b3

Table 2: Percentage change computational matrix

Where:

• area_id_start and area_id_end speak to the tile sets, where s is the begin tile, and e is the end tile.

• n_people_baseline is the all out number of individuals who relocate from s to e amid timespan t averaged over the 3 weeks before the debacle.

• n_people_crisis is the all out number of individuals relocating from s to e amid time t.

• n_diff is the difference between the count of individuals moving from s to e amid the debacle in respect to the benchmark mean.

• percent_change is the rate contrast between the count of individuals moving from s to e amid the catastrophe with respect to the benchmark mean.

Result output as shown in Fig 8 below:

Fig. 8.Populate dispalcement Diagram

This investigation portrays the fiasco maps datasets, how bits of knowledge are determined, and the means taken to guarantee that we're saving privacy.

Data and aggregation

At the point when individuals' cell phone is on with Location Services empowered, their latitudes and longitudes are gotten at customary interims. For instance, it enables us to send Safety Check warnings to those in areas influenced by catastrophic events. We have to realize where individuals have relocated. To surface these bits of knowledge, we can built up another Displacement Map.

• Challenges: what number individuals have been dislodged from their home city after a catastrophe? Which urban communities are these individuals dislodged from? Which urban areas are dislodged individuals heading out to?

• Data and Methodology: We total data from individuals utilizing mobile positioning data with location services on, at the city level. We concentrate around the number of inhabitants of individuals who were in the fiasco influenced territory amid the 5 weeks before the calamity, and who were available in their most normally happening city or their "home city" amid the week prior to the catastrophe. For this type of individuals, we at that point recognize their most basic city every week — their "current city" — in the months after the catastrophe and total that data at the city-level, just incorporating urban communities with an adequate number of individuals in the data panel to be factually significant.

• Metrics: We give home city data, including significant week by week data on urban communities in the hazardous situation. We additionally give current city data, reflecting patterns where huge gatherings of dislodged individuals moved amid every week following the catastrophe.

E. Well-being Check diagrams:

Wellbeing Check diagrams , food and medicine administration (People who are in safe zones can be advised as protected zones). Well being Check enables individuals to associate with loved ones amid a debacle. Individuals are welcomed that may be influenced by the emergency to check in safe. When they have checked in, they would then be able to welcome others that may be influenced. Along these lines, solicitations to check in safe spread to individuals on apps like Facebook [7] who are likely influenced by a catastrophe. We can total and share Safety Check information to demonstrate where individuals are showing that they are sheltered and safe. This information resemble as shown in Table 3 below: \

Table 3: Safe Ratio computational matrix

CRISIS_NAME	TIME_ WINDOW	AREA _ID_S TART	N_INV ITED	N_ SA FE	SAFE_ RATIO
"Flood in Country X"	t1	a1	x1	y1	y1 / x1
"Flood in Country X"	t2	a2	x2	y2	y2 / x2
"Flood in Country X"	t3	a3	x3	y3	y3 / x3
"Flood in Country X"	t4	a4	x4	y4	y4 / x4
"Flood in Country X"	t5	a5	x5	y5	y5 / x5

• n_invited is the complete number of individuals invited to Safety Check who are situated in region a.

• n_safe is the complete number of individuals who checked in safe amid time t or any earlier time in region a.

• safe_ratio is the extent of individuals in region a who have looked at in safe of the number welcomed.

Result output as shown in Fig 9 below

Fig. 9.Wellbeing Check diagrams

When you mark yourself as safe sheltered, Application can lead you to a page that demonstrates others' wellbeing statuses, just as posts from individuals offering and searching for assistance in the zone. "You may be protected, however that doesn't mean you needn't bother with assistance." You'll have the option to click "Discover Help," browse classifications, for example, Food and Water, Transportation, Shelter and Baby Items, and afterward make a post that further clarifies what you need. On the off chance that you need to offer assistance, similar to an extra room or additional sustenance, you can look through the posts and legitimately message somebody who needs your assistance, or make another post with subtleties of what you can give.This study additionally recommends utilizing 'people group help' and open source document platform' in emergency circumstances, with a large number of columns of what individuals could offer. At the point when a high number of individuals are posting about an occurrence in a given zone, Mobile App will consequently tell those individuals and inquire as to whether they're OK. An individual would then be able to check themselves as protected and brief companions to do likewise, rather than Mobile App sending warnings to everybody. That change is a push to give individuals near fiascos more power in choosing when Safety Check is useful.Contextual analysis: Something apparatuses like Safety Check and Community Help could conceivably forestall. "Data is completely the bedrock of helpful aid projects". We can utilize mobile app Safety Check information to make live debacle maps that rapidly feature where gatherings of individuals are checking in safe, and furthermore where they are not checking in safe.

V. CONCLUSION

This project (Generation of debacle maps) could support NGOs and agencies, all the more viably plan and react to cataclysmic events. With these new diagrams and maps, help relief agencies can get cutting-edge information on where individuals are located, where people have been dislodged from their homes , what is the status of electricity in the affected area, historical pattern of flood zones and people's basic need (food, clothes, medicine, shelter, safety & education) analysis. With part of good expectations, when debacles do strike, these instruments keep on helping networks recoup and modify. We can assess the spatial inclusion of our information by contrasting the Disaster Maps Density datasets with open-source populace density datasets. By making this correlation, we can plainly convey to help offices, any territories that are likely not enough secured with the help of debacle maps populace dataset.Challenges: To get better results, which territories the drones should seek? How can we do the deep learning on the live data of people? Imagine a scenario in which we do reviews of regions that are being relinquished, potentially to due to crumbled structures or different kinds of foundational infrastructure harm.

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AUTHORS PROFILE

First Author: Mohammad Nasim has extensive live experience of 20+ years for many large scale system projects in developing and architecting software solutions using various latest COTS and open source technologies and products. I am working here on a clients facing role and working as a senior architect in Pubic authority of electricity and water, Muscat, Oman. I do have working and architect knowledge on data center (Custom/Cloud), platforms (SASS, IAAS, PASS) , Technology (COTS, Open Source), storage (Mobile ,Server) , database (Cloud, Oracle, Microsoft SQL, PostgreSQL) , web services (REST, Micro-services) , security(Internet) and application performance and testing. I have completed my Master's Degree of Technology in Computer Science (M.Tech.-CSE) from Shri Venkateshwara University, Gajraula, U.P., India. Now I am persuing my Philosophy in Doctorate in Computer Science (Ph.D.-CSE) from Lingaya's University, Faridabad, Haryana, India. I have participated in IInd International Conference of System Modelling and Advancement in Research Trends (SMART) organized by Teerthanker Mahaveer University, Moradabad, U.P., INDIA and Academic Journals Online in Nov 13 and presented a paper titled "Mobile GIS on ArcGIS technologies for Android". I have participated in International Conference of Advance Research and Innovation organized by International Journal of Advance Research and Innovation, Delhi, INDIA and Delhi Technological University, Delhi, INDIA in Feb 14 and presented a paper titled "Cross Platform Mobile GIS System for Data Collection based on GPS and emerging GIS Technologies". I am member of IEEE since Mar 2016 – Present.

Second Author: **Dr. G.V. Ramaraju's** recent engagement has been as Pro Vice-Chancellor, Lingaya's Vidyapeeth, Faridabad, India since August 2014 concentrating on Innovation and R&D. His earlier positions include Senior Director and Group Coordinator of R&D in IT, Department of Electronics & Information Technology, Ministry of Communications &IT, Government of India and Managing Director & CEO, Media Lab Asia (now Digital India Corporation) till June 2014. As Group Coordinator of R&D in IT at DEITY, he was programme coordinator of Centre for Development of Advanced Computing, India and the many R&D projects of the Ministry of Electronics and IT including Bioinformatics, Perception Engineering, Free and Open Source Software, Green computing, Ubiquitous Computing, High Performance Computing, Promotion of Technology Innovation and Entrepreneurship Development, promotion of protection of intellectual property of MSME sector, nano-electronics and nanotechnology, development of R&D framework etc till 2014. He played a very pivotal role for formulating and enabling the initiation of the programme "IT Research Academy" for capacity and capability building of R&D in ICTE across the country in India. He has taken big steps for promotion of R&D in Nanoelectronics in the country in a major way in setting up many Centers of Excellence on nano-electronics and nanotechnology across the country at many Indian Institutes of Technology and Universities. He had been passionately engaged in the ICT for Development sector and led the development and deployment projects of Media Lab Asia especially in the areas of ICT for livelihoods generation and enhancement, ICT for agriculture, primary health care, education, empowerment of the disabled in multi stakeholder environment involving academic and R&D institutions, Government, NGOs and Industry.He earned his PhD in Physics from Indian Institute of Technology New Delhi, India in 1982 and Masters Degree in Physics with electronics specialization from Andhra University, Visakhapatnam, India in 1976 with distinction. He has been at first position all through his scholarly profession. He was recipient of many scholarships awards including the Fellowship under Indo-US exchange of Scholars, National Merit Scholarship, CSIR Fellowship, IIT Delhi Fellowship etc. His interests include ICT for Development sector, IOT, nano-electronics, high performance computing, innovation and R&D promotion, entrepreneurship development etc. He has published around 40 papers in reviewed journals and conferences in the areas of Information Technology, ICT for development, Nano-technology, plasma science etc.