ANALYSIS OF LOCAL AND REMOTE MAPPERS' OPEN GEOGRAPHIC DATA CONTRIBUTION TO OIL SPILL DISASTER RESPONSE IN NIGER DELTA REGION, NIGERIA

Victor Ndubuisi Sunday[1,2,3]*, Raphael Ike Ndukwu[2,3], Maria Antonia Brovelli[4]

[1]Department of Geography and Environmental Management, University of Port Harcourt, Nigeria - victor.sunday@uniport.edu.ng
[2]Department of Geoinformatics and Surveying, University of Nigeria, Enugu Campus, Nigeria - raphael.ndukwu@unn.edu.ng
[3]Unique Mappers Network, Nigeria - uniquemappersteam@gmail.com
[4]Department of Civil and Environmental Engineering, Politecnico di Milano, Italy - maria.brovelli@polimi.it

Commission IV, WG IV/4

KEY WORDS: Remote Mappers, Local Mappers, OpenStreetMap, Oil Spill, Disaster Response Mapping, Open Mapping, Open Geographic Data, Building Footprints

ABSTRACT:

This paper provides a comparative analysis of the contributions of Local Volunteer Mappers (LVM, resident in Nigeria) and Remote Volunteer Mappers (RVM, not resident in Nigeria) in an organized crowd-sourced disaster response mapping using OpenStreetMap. The study sampled two Local Government Areas in Ogoni land - a major oil spill disaster vulnerable area of the Niger Delta Region. The study engaged mappers using the Humanitarian OpenStreetMap (HOT) tasking manager for Tai (Project task 6358, with 596 grids –RVM) and Gokana LGA (Project task 6359, with 706 grids –LVM), respectively in a Mapathon battle challenge. The result shows that project task 6358 was completely mapped and validated in six months, while project task 6359 took 28 months. Each of the 56 RVM spent an average of 20.77 minutes/grid, generating a total of 16,416 edits of 13,552 building footprints and 858km of roads. The 173 LVM spent an average of 41.1 minutes/grid to generate 18,367 edits of 14,983 building foot prints and 521km of roads. The study also showed that a total of 103 RVM joined but only 56 completely mapped the task within six months whereas 173 LVM joined and completely mapped the task within 28 months. Demographic characteristics of both categories of mappers showed that 52% of the RVM were advanced mappers whereas 72% of the LVM were beginner mappers on the HOT Tasking Manager. Conclusively, the lacuna or differential response of RVM and LVM requires investigation in terms of geographic context, digital citizenry, economic disposition and demographic characteristics of online volunteer mappers.

1. INTRODUCTION

Open mapping leverages on volunteer mappers mobilized and engaged from the public. Volunteers most often are trained and coordinated virtually to carry out dedicated mapping tasks, irrespective of their geographic location, profession and academic background. In this study, the engaged volunteer mappers are categorized into two namely: the Local Volunteer Mappers (LVM, resident in Nigeria) and Remote Volunteer Mappers (RVM, resident outside Nigeria). The study sampled two out of the four Local Government Areas (LGAs) in Ogoni land, a major oil spill disaster vulnerable area within the Niger Delta region of Nigeria. Following the hazardous impact and damage of Ogoni land by oil spill disaster over the years, United Nations Environment Program (UNEP) assessed that the environmental restoration of Ogoni land would require coordinated efforts on the part of government agencies at all levels, industry operators and communities. UNEP also presented its recommendations as a major opportunity to bring new investment, employment opportunities and a culture of cooperation to Ogoni land in addition to drive improvements in the environmental and health situation on the ground (UNEP, 2011). To effectively implement the UNEP recommendations for the restoration of Ogoni land, there is a need for geographic data that would provide critical building footprints in the area, especially, to identify and access vulnerable oil spill communities. Maps produced would be used by government agencies and other stakeholders working to implement the UNEP report on Ogoni land restoration as well as serve for multi-sectoral data use cases and sustainable development goals (Štampach et al., 2021) Therefore, the study was guided by the following objectives: mobilization and training of volunteer mappers, delineation of online mapping tasks, analysis of mapathon coordination, analysis of volunteer mappers' level of participation, and contribution to the humanitarian response mapping of vulnerable oil spill disaster communities in the sampled study area.

*Corresponding author.

2. RELATED WORKS

The use of OpenStreetMap for crowdsourced mapping is a focal point of research globally in the emerging field of OSM Science with potential applications in Nigeria for geospatial data access, disaster response mapping and sustainable development (Grinberger et al., 2022). Geoinformation is critical in providing effective and rapid response in mapping of geohazards such as flooding, oil-spill, earthquakes, landslides and gully erosion. Crowd-sourcing is derived from a conceptual business operation of outsourcing activities to a large group of participants to ensure optimal performance at a reduced or no cost at all. It requires cooperation and participation for a public good, that leverages a 'common-based peer production' that is voluntary with non-cost implication. Participants work independently and voluntarily with the individual interest to achieve a collective goal (Hacklay, 2010; Park, Johnston, 2017).

Globally, geohazards are serious threats to life, property and environmental sustainability, and often require rapid response mapping of vulnerable communities. These geohazards become disastrous where their occurrence is beyond the management capability of the immediate community. Disaster events are location based and, as such, require critical geospatial data for analysis, early warning system development as well as effective rapid response mapping and emergency management (Sunday et al., 2016). Rapid response mapping is time-dependent and also relies on geospatial data that must be up to date and accurate. Crowd generated geospatial data enables rapid acquisition of data, but spatial data infrastructure enhances the quality of data acquired in terms of data accuracy, completeness and usage. Some authors still argue that there are conflicting issues about crowd-sourced data in terms of quality and accuracy (Koswatte et al., 2015).

Most authors agree that Volunteer Geographic Information (VGI) is heterogeneous as a result of its collaborative process of map production by volunteers. Studies based on this consensus, recommend three components for description or assessment of volunteer mappers, namely: motivation, action and outcome. Consequently, when locations and features are mapped (action), individual participant interest (motivation) will result into a heterogeneous dataset (outcome) production (Budhathoki et al., 2010, Rehrl et al., 2013).

The earlier concern of volunteer mappers credibility towards data contributed is no longer primary issue as studies showed that OSM data quality assessment compared with authoritative datasets from different countries are accurate in terms of positional accuracy and completeness (Begin et al., 2013, Arsanjani et al., 2015, Broveli et al., 2016, Yeboah et al., 2021). However, this study, leverages on the research gap as it applies to the use of OpenStreetMap for the assessment of participation level of volunteers for rapid response mapping in Nigeria.

3. METHODOLOGY

3.1 Study Area

Rivers State lies within latitudes 4°20′ N and 50°44′ N, and longitudes 60°20′ E and 70°35′ E. It is bounded by Abia, Akwa Ibom, Anambra, Bayelsa, and Imo states as well as the Atlantic Ocean. Geologically, Rivers State is located within the coastal lowland plains of the Niger Delta sedimentary formation. It is a land of an extensive fluvial alluvium with average slope ranging between 30 and 50 degrees in a NWSE direction. Its poor drainage is usually attributed to the low relief and gentle slopes of the region. The pattern of settlement across the region follows dry land availability in the mangrove swamp and the hinterland of the Delta. The Niger Delta region in general, is a potential disaster region due to the extensive exploration of crude oil. Both oil and non-oil activities impact negatively on its biophysical environment. Aquatic, terrestrial and groundwater pollution as well as loss of biodiversity and loss of lives and properties are some of the environmental consequences of socioeconomic activities in the region.

Rivers State is known as the hub of oil exploration industries and inevitably the epicentre of oil spill disaster in Nigeria and the Niger Delta in particular. The state is highly vulnerable to oil spill disasters that occur in and around oil producing communities. The state is not only vulnerable to oil spill disaster but also to flood and other vulnerabilities that are peculiar to the Niger delta region. Administratively, Rivers State consists of 23 LGAs, and four of these: Eleme, Khana, Gokana and Tai, that make up the Ogoni Land (Figure 1) are so ravaged by oil spill disasters as to attract global attention. For the purpose of this study, two LGAs, namely Tai and Gokana (Figure 2) were sampled and delineated for mapping response by LVM and RVM.

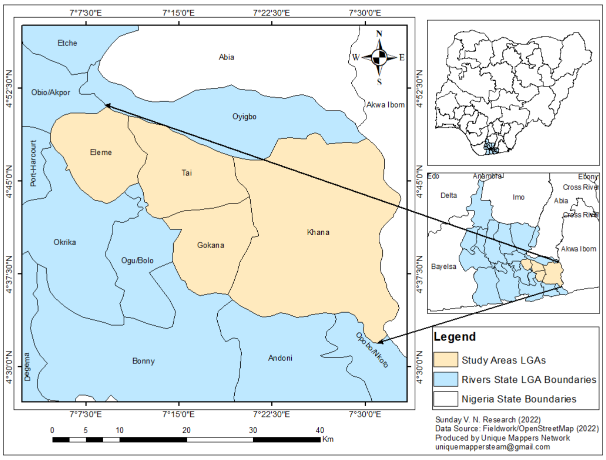


Figure 1: Ogoni Land LGAs, Rivers State, Niger Delta Region, Nigeria

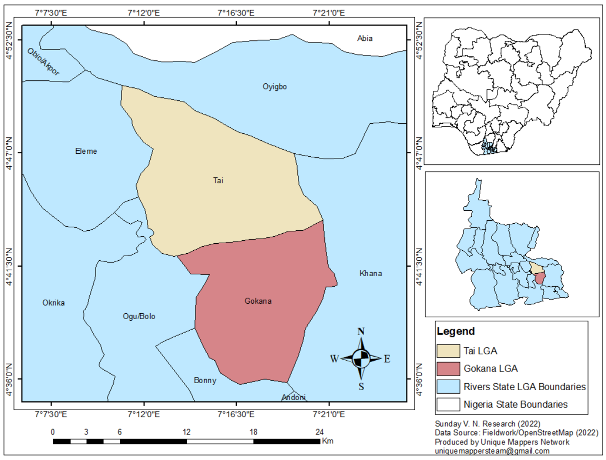


Figure 2: Tai and Gokana LGA Study Location in Rivers State, Nigeria

3.2 Data

The study adopted a sample survey to mobilize and capture the population of volunteer mappers engaged in the project. To ensure that equal opportunity is given to volunteers for crowdsourced mapping with OpenStreetMap, the study released an online event registration form to mobilize potential volunteer mappers from within and outside Nigeria. Thereafter, a questionnaire was sent to the actual mappers via the HOT tasking manager project for each LGA. Data collected was used to analyse demographics of RVM and LVM.

3.3 Materials

To host a mapathon for each of the projects for the RVM and LVM, the study made use of available in-person and virtual facilities to provide training for the mappers. Both RVM and LVM require personal laptop/desktop computers and internet-enabled devices to effectively participate in the project. In this study, crowdsourced mapping techniques involved the following stages: mobilization, training and online mapping activities using the globally accessible geospatial database system and web-map of OpenStreetMap.

Subsequently, the mappers were engaged in a rapid response geospatial data creation and online mapping of sampled vulnerable oil spill communities in the Niger Delta. The online mapping activities (Mapathon) were categorized into three stages of gamification tagged: Mapathon Battle for Vulnerable Communities Seasons 1, 2 and 3. For this Mapathon approach, gamification technique was applied to coordinate the mapping process to trigger and motivate crowd-sourced online mapping activity, based on the motive-incentive-activation-behaviour model for crowdsourcing. Gamification technique is an activity-based approach that engages and motivates participants to carry out a definite task voluntarily towards a conclusive objective or goal by presenting such tasks as a game or contest (with inherent game design elements and game thinking) in a crowdsourcing activity.

3.4 Mobilization and training of volunteer mappers

A purposive sample size of 200 Local Volunteer Mappers were mobilized and recruited from different parts of Nigeria and the organized campus teams of Unique Mappers Network, Nigeria, the Youth Mappers chapters in Nigeria, and the rest of African countries. To engage an organized and coordinated team of volunteer mappers from Nigeria the researchers mobilized, established and coordinated the following campus teams; Unique Mappers Team (University of Port Harcourt), Ignatius Mappers Team (Ignatius Ajuru University of Education, Port Harcourt), Lion Mappers Team-Enugu and Lion Mappers Team-Nsukka (both in the University of Nigeria), ABSU Mappers Team (Abia State University, Uturu), IMSU Mappers Team (Imo State University, Owerri), Unique Mappers Team (Federal University of Technology, Owerri), UniMaid Mappers Team (University of Maiduguri, Borno state), Oyo Mappers Team (Federal School of Surveys, Oyo), Unizik-Unique Mappers Team (Nnamdi Azikiwe University, Awka), and Uniuyo Mappers Team (University of Uyo). Figure 3 shows the samples of mobilization campaign flyers used to facilitate virtual and in-person training as well as mobilize LVM trainees from some of the campus teams listed by the project.

The study also created WhatsApp groups for each of these campus teams for the purpose of coordinating the local volunteer mappers for response mapping using the OpenStreetMap. These teams and their volunteer mappers were trained and signed-up to contribute geographic data to OpenStreetMap as a local community of volunteer mappers. They were given the guideline to map as contestants for mapathon battle sessions covering the mapping project area. Mapathon trainings were facilitated in-person for most of the campuses and virtually for nationwide mobilization.

In addition, training video clips were shared through the WhatsApp groups. A target of 200 RVM and LVM were mobilized for the study with social media publicity on Eventbrite platform tagged as: Mapathon Battle Campaign for Vulnerable oil Spill communities in Nigeria. The data collected from the registered participants as well as questionnaires administered to actual mappers guided the descriptive analysis and graphic representation of mobilization and training aspect of the study. Figure 4 shows sample photographs of in-person training sessions at various university campuses in Nigeria, where, the researchers mobilized trainees to establish a team of LVM.

3.5 Delineation of Mapping Task Projects for Oil Spill LGAs in Ogoni Land

Delineation of mapping tasks for RVM and LVM was carried out using the Humanitarian OpenStreetMap Team (HOT) Tasking Manager. The HOT Tasking Manager is an open-source software developed with a Python 3.6 coding that runs in a migratory

(a) Nationwide Webinar

(b) Lion Mappers Team

(c) Unizik Mappers Team

(d) ABSU Mappers Team

(e) Oyo Mappers Team

(f) Lion Mappers Team

(g) Unique Mappers Team

(h) Unizik Mappers Team

Figure 3: Samples of campaign flyers and mobilized LVM trainees for Nigeria

client database server on the GitHub HOT tasking manager API. The tasking manager database is structured into two, namely, the Client Development (Angular JS) and the Server Development (Python). The client development provides global dependency, application dependency, local testing and unit testing functionalities. This web-based software was developed as a mapping tool for the Humanitarian OpenStreetMap Team to facilitate crowd-sourced collaborative mapping activity in OpenStreetMap.

The tasking manager helps to divide or split up a mapping project into smaller tasks that will enhance rapid mapping with many mappers working at the same time on the entire delineated mapping task project. It displays the areas or grid to be mapped, the completed areas, and the area that needs validation for data quality assurance. The tasking manager gives opportunity for distribution of tasks to many individual mappers as mapping targets, and helps to check the progress of mapping as well as the tags and changeset comments (https://tasks.hotosm.org/about).

For this project, the boundaries of the sampled LGAs (Tai and Gokana) were extracted from the Nigerian administration dataset and imported into the tasking manager. The areas of interest were

(a) Unizik—Unique Mappers Team

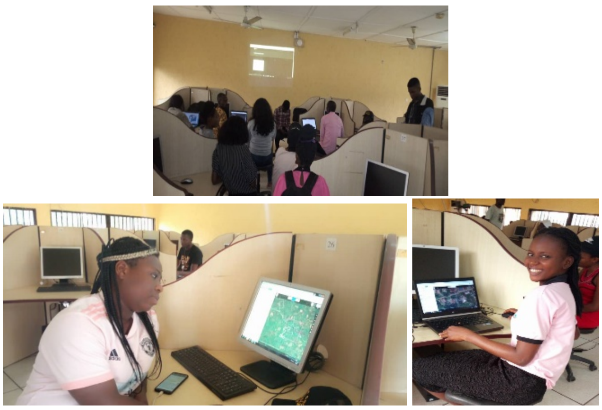
(b) Lion Mappers Team

(c) ABSU Mappers Team

(d) Ignatius Mappers Team

(e) IMSU Mappers Team

(f) Non-Student Session



(g) Unique Mappers Team-Port Harcourt

Figure 4: Sample Photographs of In-Person Training Sessions for LVM in Nigeria

gridded for random or direct task selection of 596 and 706 grids, respectively. To ensure that mapping of spatial entities of buildings and roads are appropriately tagged and credited to both individual and team mappers, hashtags were provided in the task manager's changeset comment such as #YouthMappers #OgoniOilSpillCommunities, while individual mappers would add a hashtag for their team and gender identification such #LetGirlsMap, #LionMappersTeam-EnuguCampus, #UniqueMappersTeam etc. Figure 5 shows a completed 596 gridded mapping task by RVM for Tai LGA mapping response, while Figure 6 represents the 706 gridded mapping task for LVM response mapping of Gokana LGA.

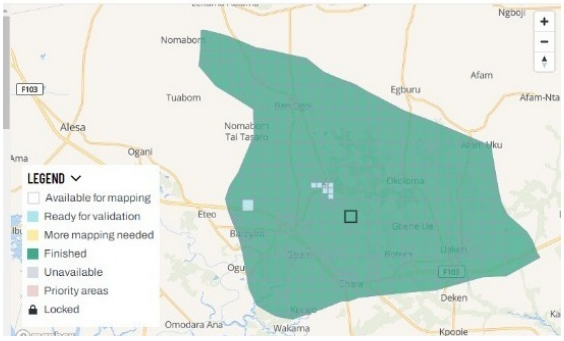


Figure 5: Tai LGA delineated HOT Tasking Manager Project 6358

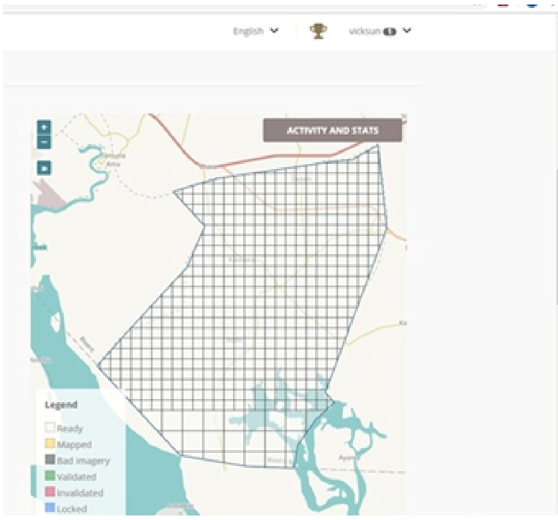


Figure 6: Gokana LGA Delineated HOT Tasking Manager Project 6359

3.6 Analysis of Mapathon Coordination

This aspect of the study focused on the practical session of engaging the volunteers online to map delineated tasks for each LGA. Both RVM and LVM had coordinated sessions of mapathon during which buildings and roads were digitized using the HOT tasking manager editing tools. Mapathon coordination provides opportunity for all level of mappers by experience to be guided on data quality and motivated on a progressive contribution of data in OpenStreetMap. The study leveraged on progressive mapathon coordination to drive organized online volunteer mappers to respond to the two LGAs. In-person mapathon was also coordinated at various university campus mapathon centres to engage the youths. Figure 7 is a workflow diagram of OSM Mapathon Infrastructure and Geostack for engagement of volunteer mappers.

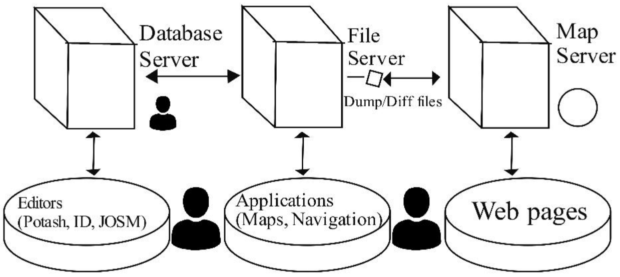


Figure 7: OSM Mapathon Infrastructure and Geostack. (Source: Neis (2014)

3.7 Analysis of Volunteer Mappers Level of Contribution and Performance

This aspect provides the assessment of volunteer mappers' participation in terms of contribution of building footprint and roads for each LGA. The study addressed the general contribution and performance of individual volunteer mappers by timeline, mapping experience level and the quantity of edits generated, as well as the comparative analysis of RVM and LVM. Data collected was analysed with descriptive statistics for graphical presentation.

4. RESULTS

4.1 Demographics of remote mappers

Remote mappers were mobilized from the rest of world outside Nigeria to participate in the Mapathon. The demographics of participants considered as remote mappers for this study are grouped into two: those resident in Nigeria and those outside Nigeria. From figure 8, the study revealed that 16.85% of participated mappers fell within the ages of 26-35 years, followed by ages 18-25 years accounting for 15.73% of the participants. Mappers below 18 years who accounted for 4.93% of the participants.

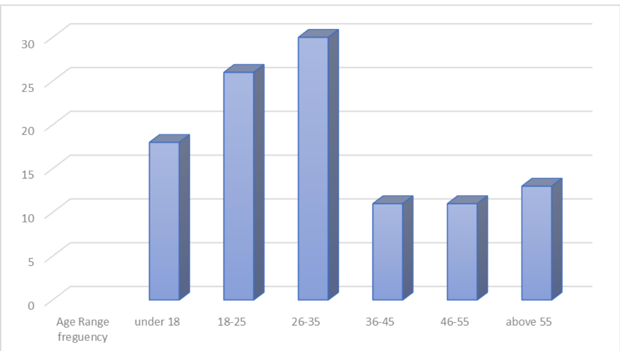


Figure 8: Age Description of Mobilized and Participated Mappers

Figure 9 shows that mobilized mappers for the study were classified into male, female and those who prefer not to disclose their status. Male participants accounted for 48.93% of the total mappers, females accounted for 19.1%, and 3.37% were those who were neutral about their gender. While Figure 10 shows the participants' professional and academic background with degree holders leading in the graph. This also indicates diversity and inclusiveness in RVM and LVM participation for both tasks.

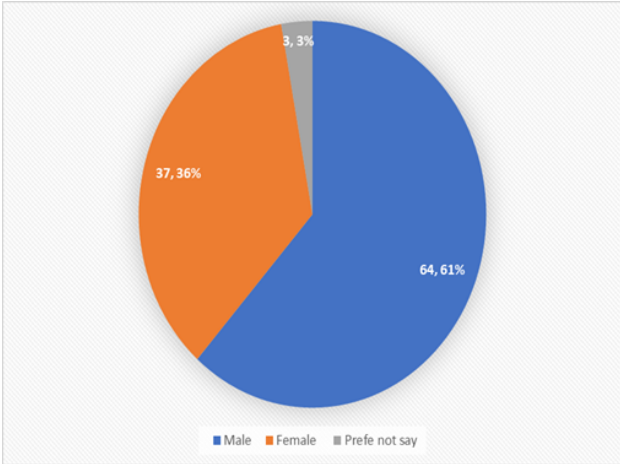


Figure 9: Gender Description of Participating Mappers

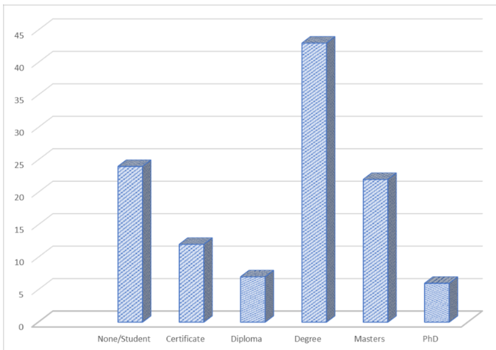


Figure 10: Professional/Academic backgrounds of participants

4.2 Training and Engagement of Volunteer Mappers in Nigeria for Mapathon

The study provided training for the engagement of volunteer mappers to drive effective participatory mapping for the designated project task. Training provides the basic procedures and orientation required by volunteers to be effectively engaged in online mapping using OpenStreetMap. Invitation to the virtual and physical training was disseminated through the Tasking Manager published project, personal invitation, Eventbrite publication, Facebook pages, WhatsApp, and other social media platforms as shown in figure 11, while figure 12 shows the experience level of mappers using OpenStreetMap.

4.3 Analysis of Volunteer Mappers Level of Contribution and Participation

To assess the level of participation of Local (mappers in Nigeria) and remote mappers (Not resident in Nigeria), two mapping projects were created in the HOT Tasking Manager for local and remote mappers, respectively to engage them in a "Mapathon Battle for Vulnerable Oil Spill Disaster Communities in Niger Delta". Project task 6358 was created exclusively for remote mappers outside Nigeria to map Tai LGA, while project task 6359 was created exclusively for local mappers resident in Nigeria to map Gokana LGA in a Mapathon battle challenge. Project task 6358 had a total gridded cells of 596 mapping tasks for online engagement of mappers, while project task 6359 had an automated grid cells of 706 mapping tasks due to differences in the size of the area.

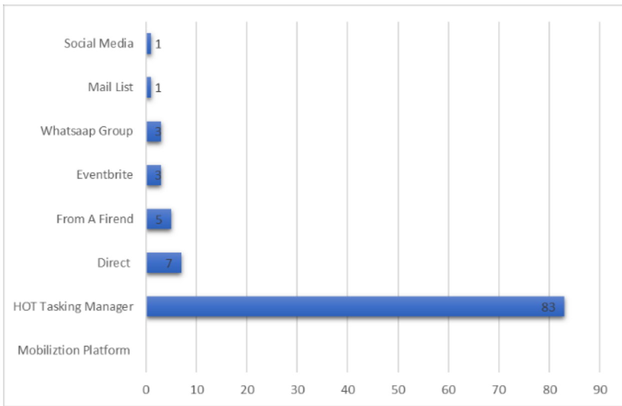


Figure 11: Mapathon Publicity Platforms for Mobilization of Mappers

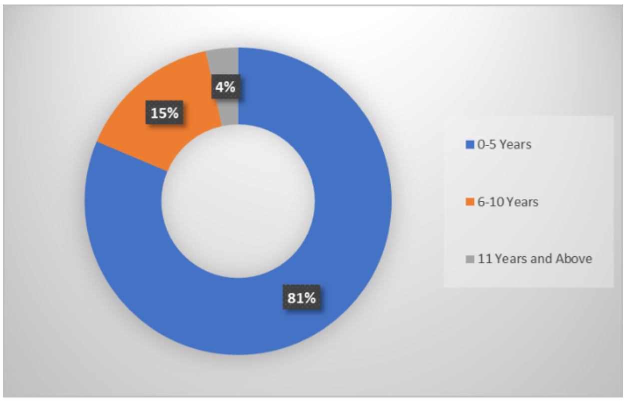


Figure 12: Experience of Volunteer Mappers by Years

The Mapathon unveiled the following research results: Engagement of remote mappers for project task 6358-Tai LGA shows that out of the 596 tasks completely mapped, only 13 were yet to be validated after 2 years of creating the project. This is as a result of archiving the project and diverting attention to urgent tasks. The project recorded a total of 16,416 edits comprising 13,552 buildings and 858km of roads mapped in Tai LGA within the timeline of the study. The demographic characteristics of the contributors to project 6358 on the basis of HOT Tasking Manager users by experience and level shows that 50% were advanced mappers and 100% had more than 1 year mapping experience. The project engaged a total of 56 contributors by mapping and validation. All mappers and validators by experience had used the tasking manager for more than one year while their mapping levels ranged from 40% for beginner mappers, 10% for intermediate to 50% for advanced mappers.

The project timeline as illustrated by the graph shows that mapping and validation of the Tai LGA task commenced on the same date: 6^{th} August, 2019 at the rate of 12% mapping and 2% validation. Mapping progressively increased to 64% on the 4^{th} day and got to its peak on the 9^{th} day being 15^{th} August with 99% of the entire task mapped. However, validation of the mapping task had a straight curve with the peak of validation being the 12^{th} of September with 95% of the task being validated. By 8^{th} January, 2020, being 6 months of the project, 100% of the tasks were completely mapped, while 13 of the 596 tasks were yet to be validated. The timeline statistics also shows that an average of 20 minutes and 46 seconds was spent per task to map a total of 583 tasks of 16,416 edits. Also, an average of six minutes and 16 seconds was spent for validation per task leaving about 1 hour 21 minutes and 29 seconds to finish up the validation of 13 tasks left due to a shift to other project tasks and less passion for the project under study. Figure 13 shows Tai LGA project contribution timeline of RVM, while Figure 14 shows the OSM map of Tai before and after six months of geographic data contribution by RVM.

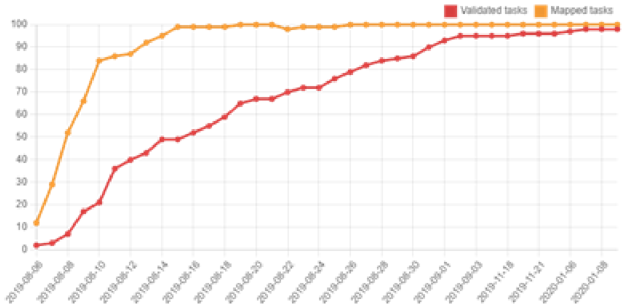


Figure 13: Contribution Timeline of RVM for Tai LGA

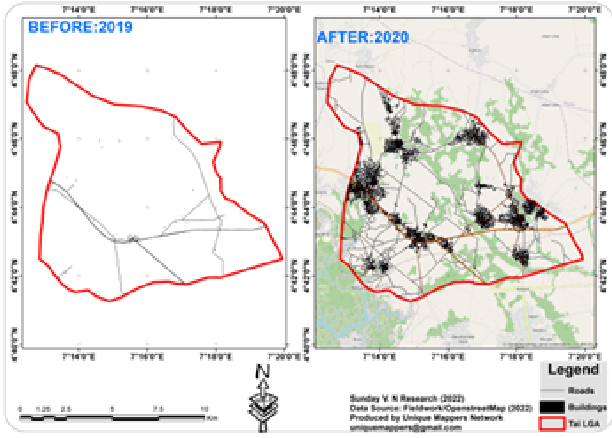


Figure 14: Before and After six months OpenStreetMap Contribution TImeline by RVM for Tai LGA

The analysis of local mappers engaged in HOT Project Task 6359 Mapathon for Oil Spil Communities in Gokana LGA revealed the following: the project delineated Gokana LGA into a total of 706 gridded mapping tasks. Relevant instructions to engage mappers effectively in the online Mapathon were given such as “This Task is Exclusively for Mappers resident in Nigeria”, “Please, do not map if you are not resident in Nigeria”, ‘‘Split task for dense building area”, “Please, use Bing imagery as default image”, “Map buildings and Roads”.

The study shows that 706 (100%) of the tasks were completely mapped except for validation of 473(67%) tasks which requires further coordination of mappers. There is no record of bad imagery and tasks left unmapped. The project also recorded a total of about 2064 changesets for mapping a total of about 18,367 edits, comprising 14,983 buildings and 521 km of roads. The project also recorded a total of 173 contributors comprising 169 mappers and 8 validators. These mappers (100%) had more than one year experience in online mapping with OpenStreetMap and are categorized into beginner mappers (72%), intermediate (6%) and advance mappers (21%). The entire project timeline for mapping and validation took a period of two years and four months (28 months) from 6^{th} August 2019 to 27^{th} December, 2021. Figure 15 shows Gokana LGA project contribution timeline of LVM, while Figure 16 shows the OSM map of Gokana before and after

28 months of geographic data contribution by LVM resident in Nigeria.

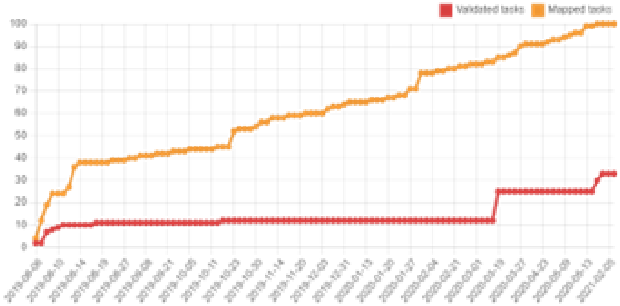


Figure 15: Contribution Timeline of LVM for Gokana LGA

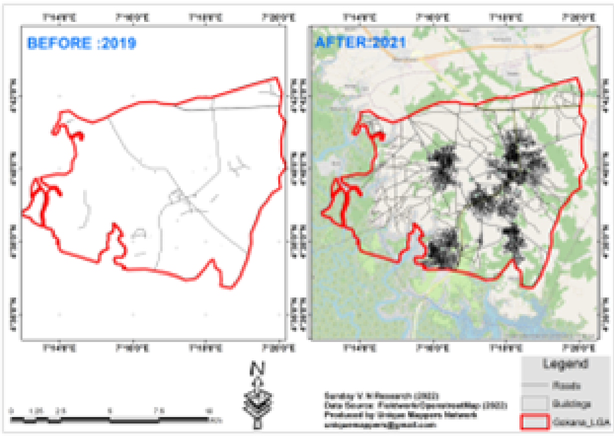


Figure 16: Before and After 28 months of OpenStreetMap by LVM for Gokana LGA

A total of 41 minutes and six seconds was spent to map each of the 706 tasks while three minutes and 15 seconds on average was spent to validate 233 tasks, leaving 25 hours, 36 minutes and 56 seconds to complete the validation of 473 tasks by further coordination and engagement of mappers for the project. Table 1 provides the summary of RVM and LVM levels of contribution and participation in mapping Tai and Gokana LGAs in OpenStreetMap for oil spill disaster response in Ogoni land.

5. CONCLUSION

Conclusively, there is a lacuna worthy of research investigation arising from this study in the mapping response level of OpenStreetMap contributors from other countries (RVM) and local mappers resident in Nigeria (LVM), indicative of geographic context, digital citizenry, demographic characteristics and economic disposition of both categories of online volunteer mappers in a rapid response mapping of vulnerable oil spill disaster communities in Nigeria.

Geographic Context: The influence of the location of online volunteer mappers as well as the location of the project might likely drive the level of participation of RVM and LVM. The level of participation of volunteer mappers may depend on their geographic disposition as RVM or LVM within a national or international context. And geographic context local knowledge may drive volunteer's level of participation. Hence, the differential

Panel A: KVM and LVM Contribution							
S/N	TYPE	LGA	TASK NO.	GRID TASKS	BUILDINGS MAPPED	ROADS(KM) MAPPED	TOTAL EDITS
1	RVM	Tai	6358	596	13552	858	16416
2	LVM	Gokana	6359	706	14983	521	18367
Panel B: KVM and LVM Participation							
S/N	TYPE	LGA	TIMELINE	MAPPERS JOINED	FINISHED TASKS	AVERAGE TIME PER TASK (MINS)	LEVEL OF EXPERIENCE
1	RVM	Tai	6 months	103	56	20.77	52% Advanced
2	LVM	Gokana	28 months	173	173	41.1	72% Beginner

Table 1: Summary of RVM and LVM Contribution and Participation

response level of volunteer mappers between developed and developing countries in OpenStreetMap may be influenced by geographic context.

Digital Citizenry: The effective, frequent access to internet might be a barrier to rapid response mapping by LVM in developing countries with high cost of internet access compared to RVM from developed countries with access to free and regular internet connectivity. This study also showed that the level of participation depends on volunteer mappers' disposition to internet access and information technology.

Economic Disposition: Volunteering takes a chunk of basic cost of time and money to deliver a public good. The economic disposition of RVM and LVM at any time affects their level of participation in OpenStreetMap humanitarian response mapping in terms of the cost of basic requirement for volunteering as well as the time.

Demographic Characteristics: Gender issues, age, educational and professional status influence the level of participation of RVM and LVM in humanitarian response mapping, especially, developing countries.

REFERENCES

Arsanjani, J. J., Mooney, P., Zipf, A., Schauss, A., 2015. Quality assessment of the contributed land use information from OpenStreetMap versus authoritative datasets. In: *OpenStreetMap in GIScience*; Arsanjani, J. J., Zipf, A., Mooney, P., Helbich, M., (Eds), Lecture Notes in Geoinformation and Cartography, Springer: Cham, pp. 37−58.

Begin, D., Devillers, R., Roche, S., 2013. Assessing Volunteered Geographic Information (VGI) quality based on contributor's mapping behaviours. In: *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Hong Kong, Vol. XL-2, Part W1, pp. pp. 456-469.

Brovelli, M. A., Minghini, M. M., Molinari, M. E., Zamboni, G., 2016. Positional accuracy assessment of the OpenStreetMap buildings layer through automatic homologous pairs detection: The method and a case study, In: *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XLI-B2, pp. 615-620.

Budhathoki, N. R., Nedevic-Budic, Z., Bruce, B., 2010. An interdisciplinary frame for Understanding volunteered geographic information. *Geomatica*, 64(1), pp. 11-26.

Grinberger, A., Minghini, M., Juhász, L., Yeboah, G., Mooney, P., 2022. OSM science—the academic study of the OpenStreetMap project, data, contributors, community, and applications. *ISPRS International Journal of Geo-Information*, 11(4), 230.

Hacklay, M., (2010). How good Is volunteered geographical information? A comparative study of OpenStreetMap and ordinance survey datasets. *Environmental And Planning B: Urban Analytics and City Science*, 37(4), pp. 682-703.

Koswatte, S., McDougall, K., Liu, X., 2015. SDI and crowdsourced spatial information management automation for disaster management. *Journal of Survey Review*, 47(344), pp. 307-315.

Štampach, R., Herman, L., Trojan, J., Tajovská, K., Rezník, T., 2021. Humanitarian mapping as a contribution to achieving sustainable development goals: Research into the motivation of volunteers and the ideal setting of mapathons. *Sustainability*, 13, 13991.

Nies, P., Zipt, A., 2012. Analyzing the contribution activity of a volunteered geographic information − the case of openStreetMap. *International Journal of Geo-Information*, 1(3), pp. 146-165.

Rehrl, K; Grochenig, S; Hochmair, H; Leitinger, S; Steinmann, R; Wagner, A., 2013. A conceptual model for analysing contribution patterns in the context of VGI. In: *Progress in Located-Based Services*; Krips, J. M., (Ed), Lecture Notes in Geoinformation and Cartography, Springer-Verlag: Berlin Heidelberg, pp. 373−388.

Sunday, V. N., Eze, C. L., Teme, S. C., 2016. Geointelligence mapping and monitoring of potential oil-spill disaster hotspots in niger delta. *International Journal of Science and Engineering Investigations*, 5(53), pp: 75-82.

United Nations Environment Program (UNEP)., 2011. Report on Environmental Assessment of Ogoni Land, Nigeria, https://postconflict.unep.ch/publications/OEA/UNEP_OEA_ES.pdf/06/2022.

Yeboah, G., Porto de Albuquerque, J., Troilo, R., Tregonning, G., Perera, S., Ahmed, S. A. K. S., Ajisola, M., Alam, O., Aujla, N., Azam, S.I., Azeem, K., Bakibinga, P., Chen, Y., Choudhury, N. N., Diggle, P. J., Fayehun, O., Gill, P., Griffiths, F., Harris, B., ... Yusuf, R., 2021. Analysis of OpenStreetMap data quality at different stages of a participatory mapping process: evidence from slums in Africa and Asia. *ISPRS International Journal of Geo-Information* 10(4), 265.