Received April 2022; | Revised May 2022; | Accepted May 2022
DOI: 10.52631/jeet.v1i1.121

RESEARCH ARTICLE

Visualization and Geo-Mapping of Philippine Fire Incidents

Joseph Jessie S. Oñate*

[1]College of Computer Studies, Camarines Sur Polytechnic Colleges Nabua, Camarines Sur, Philippines

Correspondence
*Corresponding Author.
Email: josephjessie97@cspc.edu.ph

Abstract

A fire incident is one of the most catastrophic calamities bringing injuries, loss of properties, and casualties. In the Philippines, a rapid increase in fire incidents was recorded from 2013 to 2016. This paper explores the importance of data visualization and analysis in extracting useful information that might help planning and decision-making. This study used the 2012–2016 Philippine Nationwide Fire Incident Statistics data provided by the Bureau of Fire Protection through Open Data Philippines. Data cleaning and reprocessing were conducted to develop a dynamic system known as FireStatPH using Flask. Different data visualization techniques such as choropleth maps were also used in the study to represent each dataset. FireStatPH can quickly identify the cities and municipalities with high fire incidents, injuries, deaths, and damages. It also provides fast statistics based on fire incident data. The system contributes to the planning and decision-making process in eschewing fire incidents in the Philippines.

KEYWORDS:
Fire Incident, Graphical Information System, Geospatial Analysis, Decision Making

1 | INTRODUCTION

Fire Incident is one of the most disastrous calamities affecting people and the environment. It causes injuries, property loss, and even a high number of deaths worldwide. The data on fire incidents can predict and control fire incidents. However, analyzing and interpreting such an enormous amount of information is a strenuous job (Qi, Shi, Yu, Li, 2015) [1]. In the Philippines, the government provides open datasets that are free for using, reusing, and redistribution by anyone. It also provides basic data visualization features. However, these visualization features have their limit and obstruct detailed interpretation and analysis of the data. The data on fire incident statistics is one of them, which is limited to grid data visualization.

In 2016, the Bureau of Fire Protection recorded a rapid increase in fire incidents, 19,292 in total, all over the Philippines. This is 17.59% higher than the recorded fire incidents for 2015, which accounted for 16,406 (Bureau of Fire Protection, 2017) [2]. These statistics might be visualized so that people can easily understand and interpret them. The Philippines provides the fire incident data of the different cities and municipalities for others to visualize. This study aims to develop a dynamic visualizer for the Philippine Fire Incident Statistics. The researcher uses different data visualization techniques, such as a choropleth map with a geographic information system (GIS).

This paper is structured as follows: Section 2 discusses the related works available in the literature, and Section 3 examines the dataset on which the data visualization techniques would be applied. Section 4 presents the functionalities and output of the developed visualizer. Section 5 discusses the conclusion of the study.

2 | RELATED WORK

In this section, related studies and information systems that support the concepts in data visualization on fire incidents are discussed.

2.1 | Data Visualization

2.1 Data Visualization Data visualization is a critical aspect of transmuting a large amount of data into comprehensive information for clear cognizance of people (Bayoumi. Agrawal et al. (Agrawal, Kadadi, Dai, Andres, 2015) [3] presented the opportunities and challenges in big data visualization. On the challenges, they summarized the following three items: (1) Perceptual scalability focusing on the human perception that deals with the drawback of the human eye is struggling to derive meaningful information, (2) Real-time scalability that points out the massive amount of real-time data leading to difficulty in analysis, and lastly, (3) Interactive scalability that pertains to the significance of processing visual real-time large amount of data causing a problem in the data connectivity, limited storage, and data processing capabilities, hence this study wants to solve these challenges by geographically visualizing big data on fire incidents. The researchers discussed different data reduction strategies such as sampling, filtering, and binned aggregation on the opportunities. In sample data is reduced by selecting a subset of the data from the whole population with a given probability function. In filtering, the disinformation is reduced by cosigning a subgroup based on certain conditions, and binned aggregation is a technique wherein data is grouped into a subset. These data reduction strategies convey data gathering and cleaning ideas that could help visualize big data significantly.

In the study reported by Song et al. (Song, Wu, Wong, Fong, Cho, 2016) [4], traditional data visualization tools were pointed out as static as they cause drawbacks in the portrayal of big data. Yu (Yu, 2018) [5] added that traditional data visualization techniques such as charts, lines, polar, radar, pie, and bars are used to display the difference in terms of strength in data representation. These studies show that traditional data visualization is limited and often ignored by the user. In support, (Barkwell et al., 2018) [6], (Okada, Yoshida, Itoh, Czauderna, Stephens, 2018) [7] stipulated that user experience can be improved by integrating a real-time interactive visualization such as hue-saturation-value (HSV) based data visualization and Spatio-temporal, respectively.

2.2 | Data Visualization of Fire Incidents

The study by (Alam Baroi, 2004), (Ingal, Tolentino, Valencia, Balahadia, Caballero, 2016) [8], (Balahadia, Trillanes, Armildez, 2016) [9], and (Crawl, Block, Lin, Altintas, 2017) [10] implemented different traditional data visualization techniques and GIS of fire incidents in Dhaka City, Manila, Philippines, respectively. However, these studies' conducted visualization of fire incidents is limited to a specific location and focuses only on certain aspects of assessing fire incidents.

2.3 | GIS

A geographic information system (GIS) manipulates, analyzes, and appends geographic information on a map (Sadiku, Tembely, Musa, 2017) [11]. It is being used in various aspects such as (Jiamin, Hua, Shuai, Zhonghao, Wencheng, 2018) [12] introduced the use of GIS analytics using ArcGIS to visualize and analyze big open data on environmental science focusing on urban heat islands caused by the obstruction of sea breeze by high-rise buildings in coastal areas. In addition, Zapatero et al. (Zapatero, Castro, Wainer, Houssein, 2011) [13] utilized online GIS interconnected with data visualization technologies to simulate and visualize environmental systems. Zhigang et al. (Zhigang, Liangtian, Wunian, 2010) [14] used GIS to improve the response speed and accuracy of the urban emergency management system in disaster and public safety planning and management. These studies support that Geographical Information Systems could play a big part in data visualization, aiding planning and decision-making.

3 | METHODOLOGY

This study follows a coherent flow such as data gathering, data cleaning, processing, development, and data visualization to visualize the fire incidents in the Philippines properly. It served as a master plan to attain the goals and objectives of the study. Below are the elaborated steps to explain the idea of each of the following processes.

3.1 | Study Area

The Philippines is a country of archipelago composed of 7,641 islands. It is geographically grouped into three (3) main islands, Luzon, Visayas, and Mindanao considered the 5th largest island country globally. The Philippines has a total land area of 300,000 square kilometers. The Philippines comprises 17 regions and is administratively divided into 81 provinces, consisting of 461 cities and 1,488 municipalities with a total population of 100,979,303 (Philippine Statistics Authority, 2019).

3.2 | Data Gathering

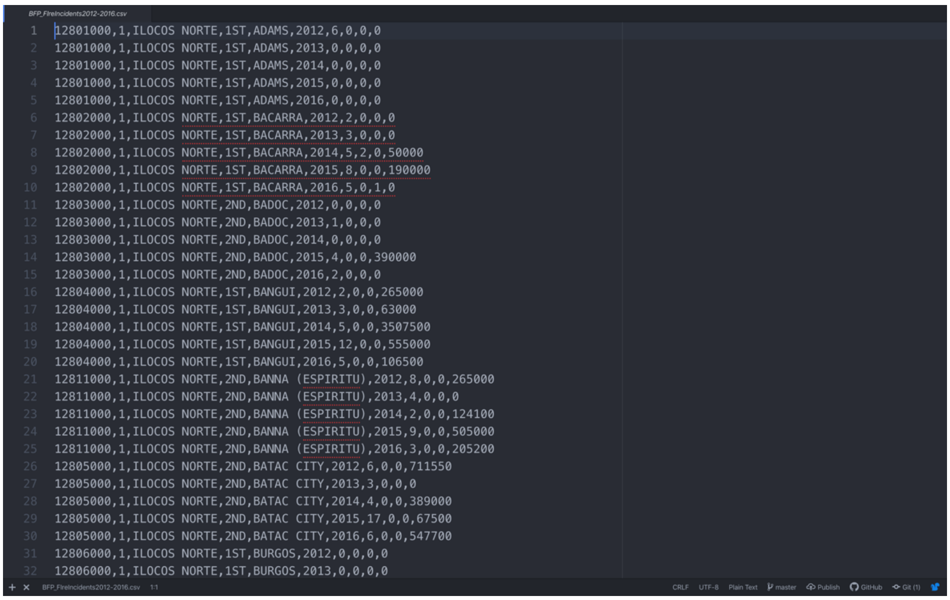

FIGURE 1 *BFP Nationwide Fire Incidents Statistics for the years 2012–2016 Dataset*

Datasets were acquired from the Open Data Philippines through the Bureau of Fire Protection (BFP). We used the BFP Nationwide Fire Incidents Statistics for 2012–2016. The dataset is in the form of comma-separated values, also known as CSV, as shown in Figure 1 . The CSV contains the Philippine Standard Geographic Code (PSGC); however, this column is not helpful for the visualization, region, province, district; municipality, or city name; year recorded; the number of fire incidents; the number of reported injuries sustained during the fire incidents; the number of reported fatalities during the fire incidents; and estimated amount of damages (in PHP) caused by fire incidents.

Along with the BFP datasets, we also used the GeoJSON Repository of Philippine Maps provided by macoymejia on Github. The repository of Philippine Maps is in the form of a JavaScript Object Notation (JSON) file, as shown in Figure 2 . It contains the feature collection, which has feature properties such as country name, region name, province name, municipality or city name, type (municipality or city), and the geometry, which consists of geometry type (e.g., polygon) and the map coordinates. The JSON file was sorted by municipality or city name in ascending order.

FIGURE 2 *GeoJSON of Philippine Municipalities and Cities*

3.3 | Data Cleaning and Processing

Datasets provided by the Open Data Philippines were in Comma Separated Values (CSV) format. They were already polished according to the requirement, which was advantageous for ease of accessing the data. However, some of the data in GeoJSON was outdated, such as city and municipality names, provinces, and others. The GeoJSON file has undergone a substantial updating to match the information on the data provided by Open Data Philippines. The researchers also developed an API to process these data into valuable and easily integrated information quickly.

3.4 | Development and Data Visualization

The researcher developed a FireStatPH system that can easily read the dataset and generate a visualization automatically for the dynamic visualization of the data. Flask, a python microframework, manages the data, and the system routes smartly, as shown in Figure 3 .

These routes have two purposes, API endpoint, and views. API endpoint routes will return a cleaned JSON data based on the request, while thoughts will return a blade template as shown in Figure 4 , which is in the form of HTML.

For UI and UX, researchers used open-source web templates crafted in various web technologies such as HTML, CSS, and JavaScript. Open-source JavaScript libraries such as Leaflet JS, Chart JS, etc., were also used to effortlessly generate different data visualization techniques. Source files are publicly available at https://github.com/iamjcoo/FireStatPH.git, and it was also implemented live on the web https://firestatph.appspot.com.

4 | RESULTS AND DISCUSSION

After several tedious steps and processes, from data gathering to development and visualization, FireStatPH could perform various visualization techniques, from simple charts to a geospatial visualization. Specifically, FireStatPH can perform the following visualization techniques.

Figure 5 displays the dashboard of FireStatPH. It includes various statistics such as the average growth rate of fire incidents, moderate injuries, casualties, and damages. The growth rate of fire incidents per year is also represented in the polar area chart. It is observed that the highest growth rate of fire incidents was recorded in the year 2013 (39.97%), while the year 2015 recorded the lowest growth rate, which was 5.68%.

```python
@app.route("/")
def index():
    return render_template('dashboard.html')

@app.route("/quickstart")
def quickstart():
    return render_template('quickstart.html')

@app.route("/dashboard")
def dashboard():
    return render_template('dashboard.html')

@app.route("/cm/<int:ryear>/")
def cm(ryear):
    return render_template('cm.html', ryear=ryear)

@app.route("/heatmap/<int:ryear>/")
def hmap(ryear):
    for x in rlist:
        if x['YEAR'] == ryear:
            continue
    return render_template('top10.html', ryear=ryear)

@app.route("/hdata/<int:ryear>/")
def hdata(ryear):
    hdata=[]
    htemp=[]
    keys = ['name', 'firei', 'injuries', 'deaths', 'damages']
    for x in rlist:
        if int(x['YEAR']) == int(ryear):
            htemp=[]
```

FIGURE 3 *GFlask Routes of FireStatPH*

```html
    <!-- Content Row -->
    <div class="row">
          <!-- Area Chart -->
          <div class="col-xl-12 col-lg-12">
            <div class="card shadow mb-4">
              <!-- Card Body -->
              <div class="card-body" style="height: 750px !important;">
                <div class="chart-area">
                  <div id="map"></div>
                </div>
              </div>
          </div>
      </div>
    </div>


  <script type="text/javascript" charset="UTF-8">
   var link = '/getJSONe/{{ryear}}/';
   var statesData;
   var statesData = JSON.parse($.ajax({type: "GET", url: link, contentType: "application/json;charset=UTF-8", async: false}).r
   var map = L.map("map").setView([13.037, 121.509], 6);

   L.tileLayer(
     "https://api.tiles.mapbox.com/v4/{id}/{z}/{x}/{y}.png?access_token=pk.eyJ1IjoibWFwYm94IiwiYSI6ImNpejY4NXVycTA2emYycXBndHF
     {
       maxZoom: 18,
       attribution:
         'Map data &copy; <a href="http://openstreetmap.org">OpenStreetMap</a> contributors, ' +
         '<a href="http://creativecommons.org/licenses/by-sa/2.0/">CC-BY-SA</a>, ' +
         'Imagery © <a href="http://mapbox.com">Mapbox</a>',
       id: "mapbox.light"
```

FIGURE 4 *Flask View Blade of FireStatPH*

Figure 6 shows the line plot of the Philippine fire incidents per year. Hovering over a particular year, the graph shows the total number of incidents, total injuries, and total casualties for that year. The blue line corresponds to the incidents, the yellow line for the injuries, and the red line for the death cases. Figure 5 indicates that a rapid increase in fire incidents was recorded from 2012 to 2016. Proving that, in 2012, 8,791 fire incidents were recorded, an increase of 3,514 was recorded in 2013, with 12,305 fire incidents. It also increased to 15,524 fire incidents in 2014, 16,406 fire incidents in 2015 and 19,292 in 2016.

Figure 7 below shows the exhibition of fire incidents using a choropleth map. Each city and municipality in the Philippines were mapped using GeoJSON, and different shades of color were used to indicate the intensity of the fire incidents using LeafletJS. Also, when the pointer hovers over a specific city or municipality, fire incidents details such as the city or municipality name, the number of incidents, the number of injuries, the number of casualties, and the estimated amount of damages are displayed (Figure 6). In 2012-2013, no city or municipality reached a thousand fire incidents; however, in 2014-2016, only the

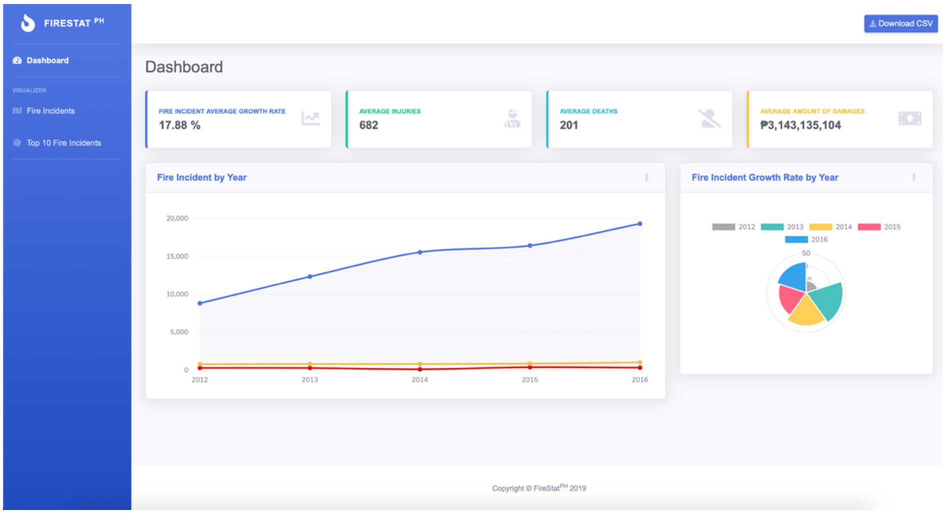

FIGURE 5 *FireStatPH Dashboard*

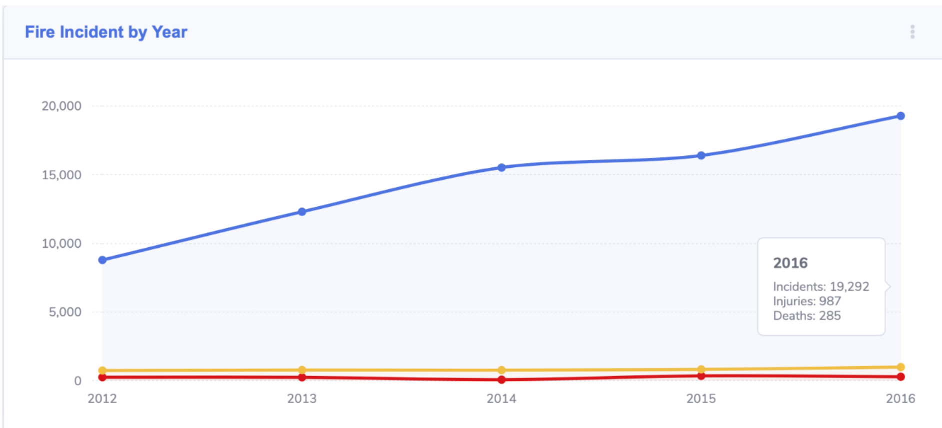

FIGURE 6 *FireStatPH visualization of Philippine fire incidents by year using Line Graph*

Quezon City took the spot to have a thousand plus recorded fire incidents. The highest fire incidents from 2012-to 2016 were recorded in Quezon City, with 865 889, 1026, 1023, and 1246 fire incidents. It also shows that from 2012 to 2016, almost all high recorded fire incidents were in highly urbanized cities such as Metro Manila, Cebu City, Bacolod City, etc.

Figure 8 shows the bubble chart of the top ten cities and municipalities with the most fire incidents. Each bubble represents the number of incidents in terms of bubble size; the more significant the bubble size, the higher the number of fire incidents. FireStatPH also revealed that Quezon City is consistent as an area with the most important number of fire incidents, followed by Manila. From 2012-to 2016, no municipality was included in the top ten towns or cities with the highest case of fire incidents. The researcher believed that FireStatPH could contribute to the planning and decision-making in eschewing fire incidents in the Philippines. With the visualization features of FireStatPH, the system can contribute to what cities and municipalities should improve their advocacies and efforts in pre-fire incident planning. The study could also help conduct new research on improving fire incident risk management in the Philippines. The researcher also perceived that the conduct of examination would greatly help improve fire incident management, whether in pre or post-planning phases.

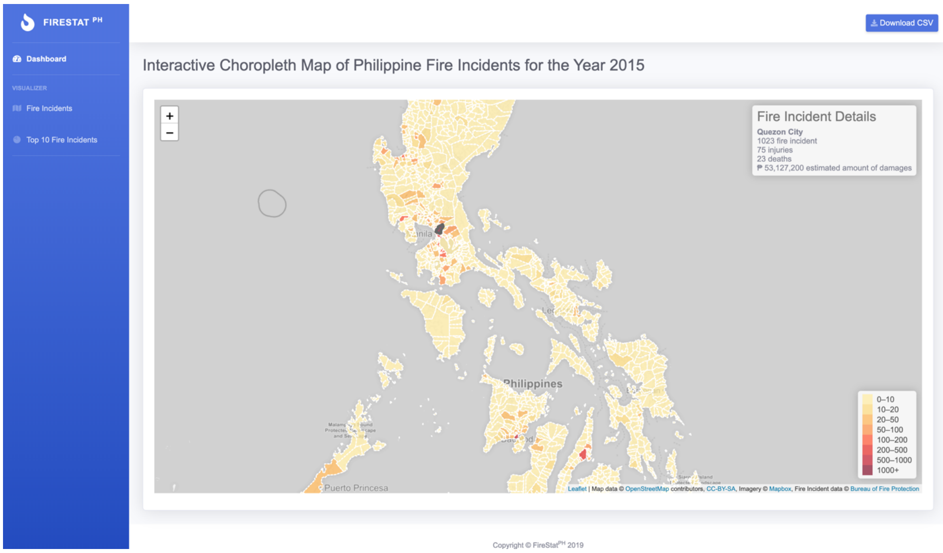

FIGURE 7 *FireStatPH visualization of Philippine fire incident for the year 2016 using a choropleth map*

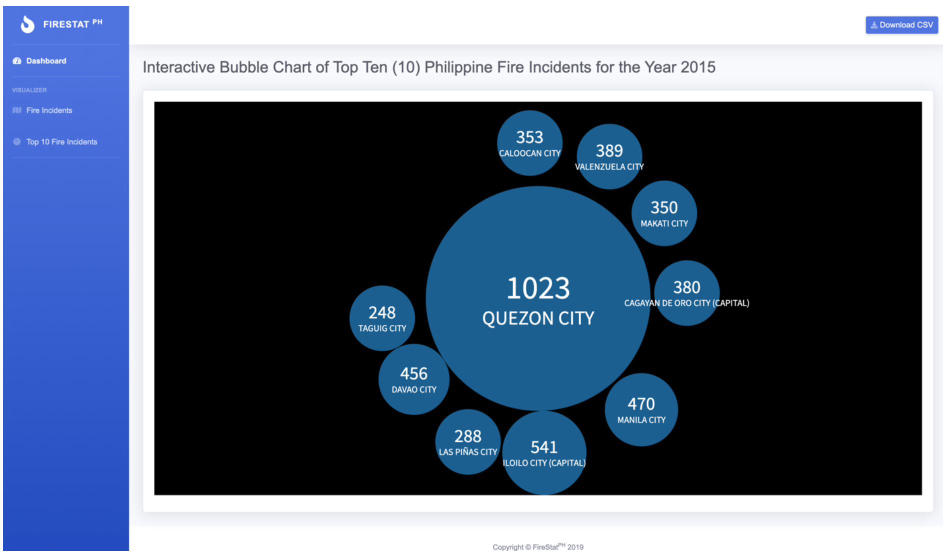

FIGURE 8 *FireStatPH visualization of top 10 Philippine fire incidents for the year 2016 using Interactive Bubble Chart*

5 | CONCLUSION

In the past few years, the Philippines has hit a record on the increasing number of fire incidents, and the recorded data on the incidents are openly available. However, these data are represented only in a tabular form, making it difficult to interpret the information. Therefore, the researchers presume that data visualization techniques might be applied to analyze these data efficiently. In this study, the researcher developed a system named FireStatPH to visualize these data dynamically. Fire incidents for the Philippines were also mapped using choropleth. FireStatPH disclosed the top ten cities with the highest rate of fire incidents over the years using an interactive bubble chart. It revealed that Quezon City was consistent as the city with the highest number of fire incidents over the past five years. The system also disclosed that most fire incidents occurred in urban areas. FireStatPH is open to new advancements and collaboration to improve its functionalities in visualizing fire incidents in the Philippines.

References

[1] Y. Qi, G. Shi, X. Yu, and Y. Li, "Visualization in media big data analysis," in *2015 IEEE/ACIS 14th International Conference on Computer and Information Science (ICIS)*. Las Vegas, NV, USA: IEEE, Jun. 2015, pp. 571–574. [Online]. Available: http://ieeexplore.ieee.org/document/7166658/

[2] Bureau of Fire Protection, "BFP Highlights of Accomplishments Calendar Year 2017," pp. 1–23, 2017. [Online]. Available: https://doi.org/8211655

[3] S. Bayoumi, K. Alghamdi, D. Alqusair, and A. Alfutamani, "Visualization of Fire Accidents in Saudi Arabia," in *2018 21st Saudi Computer Society National Computer Conference (NCC)*. IEEE, 2018, pp. 1–6.

[4] W. Song, D. Wu, R. Wong, S. Fong, and K. Cho, "A real-time interactive data mining and visualization system using parallel computing," in *2015 Tenth International Conference on Digital Information Management (ICDIM)*. Jeju Island, South Korea: IEEE, Oct. 2015, pp. 10–13. [Online]. Available: http://ieeexplore.ieee.org/document/7381890/

[5] Y. Yu, "Design of Information System for Fire Risk Evaluation," in *2018 14th International Conference on Computational Intelligence and Security (CIS)*. Hangzhou, China: IEEE, Nov. 2018, pp. 453–456. [Online]. Available: https://ieeexplore.ieee.org/document/8564345/

[6] K. E. Barkwell, A. Cuzzocrea, C. K. Leung, A. A. Ocran, J. M. Sanderson, J. A. Stewart, and B. H. Wodi, "Big Data Visualisation and Visual Analytics for Music Data Mining," in *2018 22nd International Conference Information Visualisation (IV)*. Fisciano, Italy: IEEE, Jul. 2018, pp. 235–240. [Online]. Available: https://ieeexplore.ieee.org/document/8564166/

[7] K. Okada, M. Yoshida, T. Itoh, T. Czauderna, and K. Stephens, "VR System for Spatio-Temporal Visualization of Tweet Data," in *2018 22nd International Conference Information Visualisation (IV)*. Fisciano, Italy: IEEE, Jul. 2018, pp. 91–95. [Online]. Available: https://ieeexplore.ieee.org/document/8564144/

[8] M. J. B. Alam and G. N. Baroi, "Fire hazard categorization and risk assessment for Dhaka city in GIS framework," *Journal of civil engineering (IEB)*, vol. 32, no. 1, pp. 35–45, 2004.

[9] F. F. Balahadia, A. O. Trillanes, and M. R. L. Armildez, "Temporal analysis and geo-mapping of fire incidents in the City of Manila," in *2015 International Conference on Humanoid, Nanotechnology, Information Technology,Communication and Control, Environment and Management (HNICEM)*, Dec. 2015, pp. 1–6.

[10] D. Crawl, J. Block, K. Lin, and I. Altintas, "Firemap: A Dynamic Data-Driven Predictive Wildfire Modeling and Visualization Environment," *Procedia Computer Science*, vol. 108, pp. 2230–2239, 2017. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S1877050917307585

[11] Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX 77446, United States, M. N. O. Sadiku, M. Tembely, Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX 77446, United States, S. M. Musa, and Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX 77446, United States, "Geographic Information Systems: A Primer," *International Journal of Advanced Research in Computer Science and Software Engineering*, vol. 7, no. 3, pp. 47–48, Mar. 2017. [Online]. Available: http://ijarcsse.com/docs/papers/Volume_7/3_March2017/V7I3-01303.pdf

[12] Y. Jiamin, Z. Hua, L. Shuai, W. Zhonghao, and X. Wencheng, "Application of open source GIS technology in seismic analysis and forecasting system," in *2017 4th International Conference on Systems and Informatics (ICSAI)*. Hangzhou: IEEE, Nov. 2017, pp. 1621–1624. [Online]. Available: http://ieeexplore.ieee.org/document/8248543/

[13] M. Zapatero, R. Castro, G. Wainer, and M. Houssein, "Architecture for integrated modeling, simulation and visualization of environmental systems using GIS and Cell-DEVS," in *Proceedings of the 2011 Winter Simulation Conference (WSC)*. IEEE, 2011, pp. 997–1009.

[14] L. Zhigang, Y. Wunian, and others, "Research of GIS-based urban disaster emergency management information system," in *2010 International Conference on Computer and Communication Technologies in Agriculture Engineering*, vol. 2. IEEE, 2010, pp. 484–487.

[15] R. Agrawal, A. Kadadi, X. Dai, and F. Andres, “Challenges and opportunities with big data visualization,” in *Proceedings of the 7th International Conference on Management of computational and collective intElligence in Digital EcoSystems*. Caraguatatuba Brazil: ACM, Oct. 2015, pp. 169–173. [Online]. Available: https://dl.acm.org/doi/10.1145/2857218.2857256

[16] M. Y. Ingal, R. L. T. Tolentino, M. J. Valencia, F. F. Balahadia, and A. R. Caballero, “Fire incidents management system in the city of Manila through geo-mapping,” in *2016 IEEE Region 10 Symposium (TENSYMP)*. Bali, Indonesia: IEEE, May 2016, pp. 399–403. [Online]. Available: http://ieeexplore.ieee.org/document/7519440/

How to cite this article: J. J. S. Oñate, (2022), Visualization and Geo-Mapping of Philippine Fire Incidents, *Journal of Engineering and Emerging Technologies*, *Vol. 1 No. 1*