A Geospatial Donation Platform for COVID-19 and Beyond, Leveraging Location – Based Services and Geofencing

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Abstract **– The current global scenario is characterized by epidemics and various types of disasters, severely impacting communities' health, living conditions, and economic stability. Especially during such crises, the requirement for essential necessities becomes critical. Existing solution guidelines involve receiving donated items from public agencies through an offline system to provide assistance to victims. However, this implementation faces several limitations, such as a lack of understanding of people's needs in specific areas, leading to mismatches between assistance and actual requirements. Additionally, donators lack adequate information, resulting in further discrepancies between donated items and the victims' genuine needs. The available geospatial platforms primarily support surveillance and monitoring of epidemic or disaster situations but fail to address the management of needs related to donation and receipt. Through an extensive review of the literature and related research, it was identified that a geospatial platform specifically dedicated to donation management has not yet been developed.**

To address this gap, this research proposes the creation of a novel geospatial platform using data analysis and visualization methods, complemented by the integration of geofencing technology. By employing such an approach, the geospatial platform will play a pivotal role in enhancing disaster and epidemic assistance. It will facilitate efficient data processing and visualization, overcoming the limitations faced by the current offline system. Emphasis will be placed on improving the management of needs concerning donation and receipt, thereby mitigating mismatches between assistance and actual requirements. Consequently, this platform is expected to significantly enhance the effectiveness and targeting of aid distribution during times of crises.

Keyword **– Donation geospatial platform, COVID-19, location-based service, geofencing.**

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1. Introduction

Changes that affect health and living conditions among people all over the world in this age include climate change causing various types of disasters afterward [1],[2],[3],[4] and emerging infectious disease (EID) or epidemic, i.e., COVID-19 [5],[6],[7],[8] to be handled and planned for management in each country so that their people will get least affected, and to provide assistance for victims, particularly in terms of health and living conditions among people in each area during the epidemic and disasters [9],[10],[11]. Public agencies currently have different policy for assistance in terms of subsidy [12],[13],[14], health services such as medical care in hospitals and other involved places, medicines, and medical supplies for people. However, due to the situation of COVID-19 with the unceasing number of patients during the past 3 years, people have been affected in several aspects, i.e., layoff/dismissal because of a number of closed down establishments. This affects income and expenses for survival [15],[16],[17] e.g., food expenses, health, e.g., expenses for nostrums, herbs, surgical masks, and alcohol to prevent COVID-19.

However, now there are agencies and people with efficiency to offer their assistance by donating items, food, herbs, nostrums, and surgical masks for victims. The implementation in Thailand is currently available in different ways, i.e., the pantry of sharing for donators and recipients, and donation through public agencies for distribution[18],[19],[20]. These implementations can reduce effects that have occurred. However, there are still several limitations. To clarify, there is information of the needs among people in each area, resulting in mismatch between assistance obtained and actual needs. Donators do not have any information to support their decision making on what to donate and how many because the extent of need in each area remains unknown. According to previous studies and literature review, it was found that the current development of geospatial platform for COVID-19 is mostly surveillance and monitoring of the situation in each area [21],[22],[23],[24], including analysis to predict COVID-19 risk [25],[26],[27]. However, geospatial platform for donation management has not been developed yet. Thus, this research introduced the development of geospatial platform to manage needs for donation and receipt by geographic information system (GIS), which can reduce limitations; with management geospatial platform to obtain data/information of victims' needs to relieve effects on their health and living conditions in each area of COVID-19, other epidemics, or other types of disasters in the future. The data obtained can also support planning for decision making of involved agencies.

2. Related Works

The review of related works and literatures in this research was divided into two parts, i.e., research on applying Geographic Information System (GIS) to COVID-19, and that on the development of systems and applications related to donation. The results of both topics are as follows.

2.1. Applying GIS to COVID-19

According to literature review, it was found that GIS was used to develop applications to visualize the number of COVID-19 patients in each region or area [21],[22],[23],[24], mostly visualized in dashboard, consisting of map, statistics, diagram, and spread of COVID-19 in different areas [28]. The data from this research could be used for treatment management in each area for further preparedness of public health. GIS was also used to analyze COVID-19 risk and spread in each area [29],[30]. Spatial data was used for risk analysis, i.e., land use and land cover (LULC), population density, workers, literacy, water consumption, the number of patients in each area, distance from patients' locations, and administrative districts. The results were visualized in a map of COVID-19 risk levels in each area, which was used for monitoring the incidence of COVID-19 in each area.

According to related works on using GIS to visualize spatial data, the number, spread of COVID-19 patients, and COVID-19 risk analysis, it was found that both parts were to prepare and monitor COVID-19. But it did not support management to provide assistance for people or victims in each area. However, when studying related works on using GIS for data manipulation to provide assistance for people under COVID-19 epidemic in each area, it was found that the development of applications to present medical service centers were introduced so that people could use as data as a service (DaaS) [31]. GIS web applications were developed to allow volunteers to report patient data in each area, aiding in helping and supporting the treatment process. [32]. This conformed to the introduced development of web applications to search for data of COVID-19 patients by radius or users' locations so that they would acknowledge the number and density of patients in each area and whether or not there were COVID-19 patients around in order to use those applications for prevention and monitoring [33].

There were also guidelines on using GIS and Internet of thing (IoT) for management to control COVID-19 by various means, i.e., spatial temporal analysis, volunteer geographic information (VGI), location-based service (LBS), IoT, web mapping, and satellite image-based analysis. These technologies could be used in COVID-19 management process. The results revealed that these applications could be used for health service monitoring and allocation, e.g., the number of hospital and the number of available beds, which facilitated efficient management. However, this research did not support assistance for people in each area in terms of items, food, and herbs [34].

2.2. The Development of Donation Applications

According to the review of literatures and works related to the development of donation systems or applications, it was found that the development of a donation application was introduced for blood donation in different platforms and technologies, resulting in different capabilities of the introduced systems. For the details, the development of this mobile application was introduced to support blood donation for interested donors. The system could support users to register their information and set schedule and places for donation.

The results were visualized in an online map with data visualization, i.e., donation guide, FAQ, news, and donation records [35]. The development of a mobile application prototype was also introduced to search for blood donors in fixed radiuses from locations in need. The prototype could also set the conditions of required blood groups with the use of donors' coordinates. In the research, location-based service (LBS) was used to retrieve coordinates from GPS in a user's smartphone for data processing and visualization in the application. The development of this prototype finally led to quick blood donation, and met recipients' needs in case of emergencies. It could also be used to communicate with donors [36]. Other than these, the literature review also revealed that the development of a mobile application to receive donated items was introduced. It was developed to record data of daily donated items in the database, of which results and donation records (history) were visualized. However, this research neither supports notification of recipients' needs nor spatial data analysis and visualization [37]. The development of a mobile application to visualize data of items that agencies asked for donation was also proposed. To clarify, LBS was used to retrieve coordinates of agencies for visualization in an online map so that donators could view data and choose agencies nearby to show their intention of donation. However, this research did not support data retrieval and visualization of donators' coordinates. The application lacked the capability to process data in real-time, leading to the inability to visualize the actual number of items available. For instance, if an agency requested 100 bottles of water and 5 sacks of rice for donation, but in reality, all 100 bottles of water were already donated while only rice was still needed, the application failed to display this discrepancy in data. As a consequence, the mismatch between the required and available items affected the effectiveness of further assistance management for people in need. [38].

3. Materials and Methods

This study delineated the research materials and methods into three main parts, namely: study area, data preparation, and system analysis and design.

3.1. Study Area

The study area in this research was Surat Thani Province, Thailand. The area was affected by COVID-19 situation and annual floods. However, the platform or application in this research supports the use in other areas. It also supports spatial data manipulation and visualization by retrieving latitudes and longitudes from GPS of users' smartphones.

3.2. Data Preparation

This research collected data by two methods, i.e., spatial data queried by retrieving data of base map query using Google Map API, and latitudes and longitudes of recipients as well as donators by GPS in smartphones. The next part was attribute data manipulation, consisting of different types of data, i.e., text, numeric, and image. Both parts were collected through the introduced platform and stored in geospatial database for management to provide assistance for victims under the epidemic or disasters. The details are of data, types of data, sources, and acquisition methods are in Table 1.

Table 1. Data and data sources

Data	Data Type	Data source	Method
Base map	Spatial	Google	Google Map API
Situation data	Attribute	Users	User's input
Demand data	Spatial Attribute	User's GPS People/ Victims	Geolocation People/ Victims
Donation data	Spatial Attribute	User's GPS Donators	Geolocation Donators
Thing data	Attribute	Officers	Officers
Food ingredient data	Attribute	Officers	Officers
Navigation data	Spatial Attribute	Google Geospatial database	Google Map API Geofencing
Status data	Attribute	Officers	Officers

3.3. System Analysis and Design

This research analyzed and designed the system by collecting the requirements from the situations and the problems of receipt management in the study area due to COVID-19 and local disasters. The limitations of the reviewed literatures and related works were also used to set the requirements of the developed platform. The requirements or capabilities of the system in this research consist of eight modules as shown in Figure 1. They were user authentication, spatial data manipulation and visualization, donation notification, update status, demand donate matching, geofencing, navigation, and generate reports. This research contained the different platform design than the previous ones and other platforms as follows.

- Latitudes and longitudes of donators and recipients were retrieved for navigation among work teams or officers in charge to take and distribute items.

- The application could process data to identify particular needs of recipients and donators. This facilitated donators to acknowledge data and the number of items in real time (Figure 2).
- Geofencing was used to visualize amounts of items, the number of recipients, and the number of people who needed stuffs so as to plan for travel under the conditions of such amounts in each area by fixed radiuses parallel to the shortest distances. The design process is shown in Figure 3. The application also supports item calculation, e.g., rice and dry food for cooking to provide assistance for victims.

This research designed the database for using in the application, consisting of eight tables, namely, User, UserType, Item, Needed_Item_Data, Donation_Notification, Donation_Item_List, Situation_Notification, and Food_Ingredient. The details of database design are shown in Figure 4. As for hardware and software for application development, thee hardware consisted of a server as web server laptop and smartphone, while the software included Apache Web Server, PHP, JavaScript, Google Map API, and MySQL. All of these programs are open-source software.

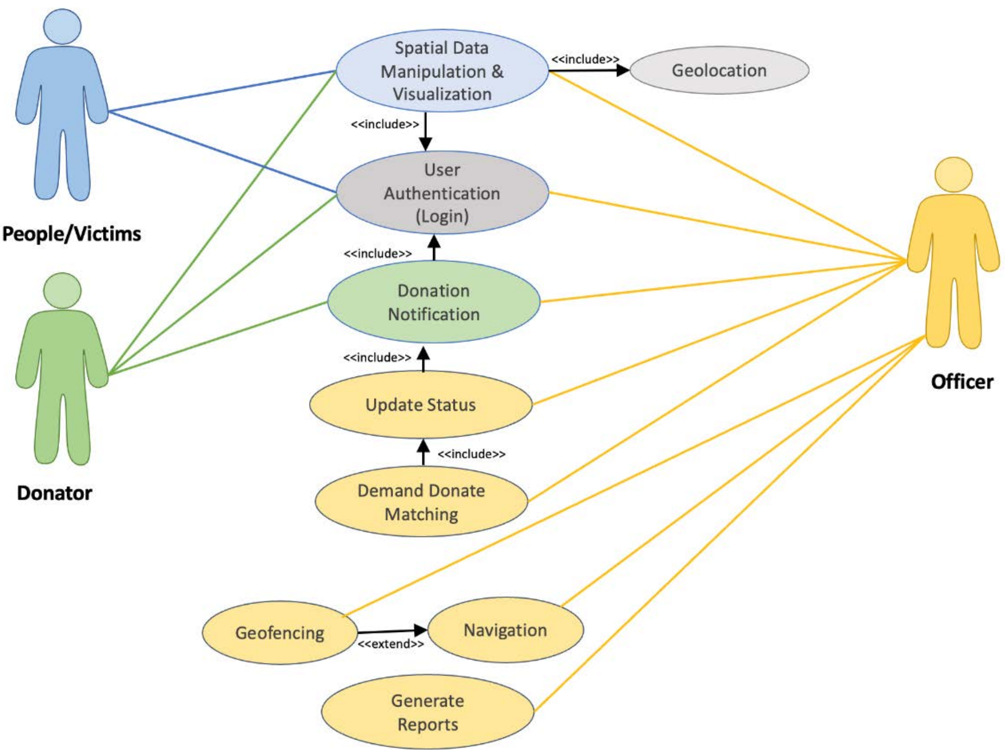


Figure 1. Use case diagram

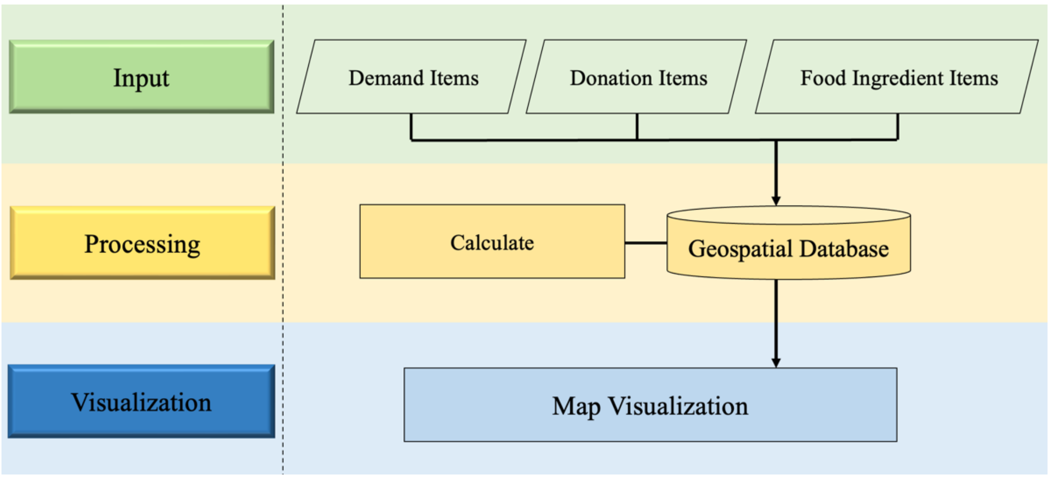


Figure 2. Real-time data calculation

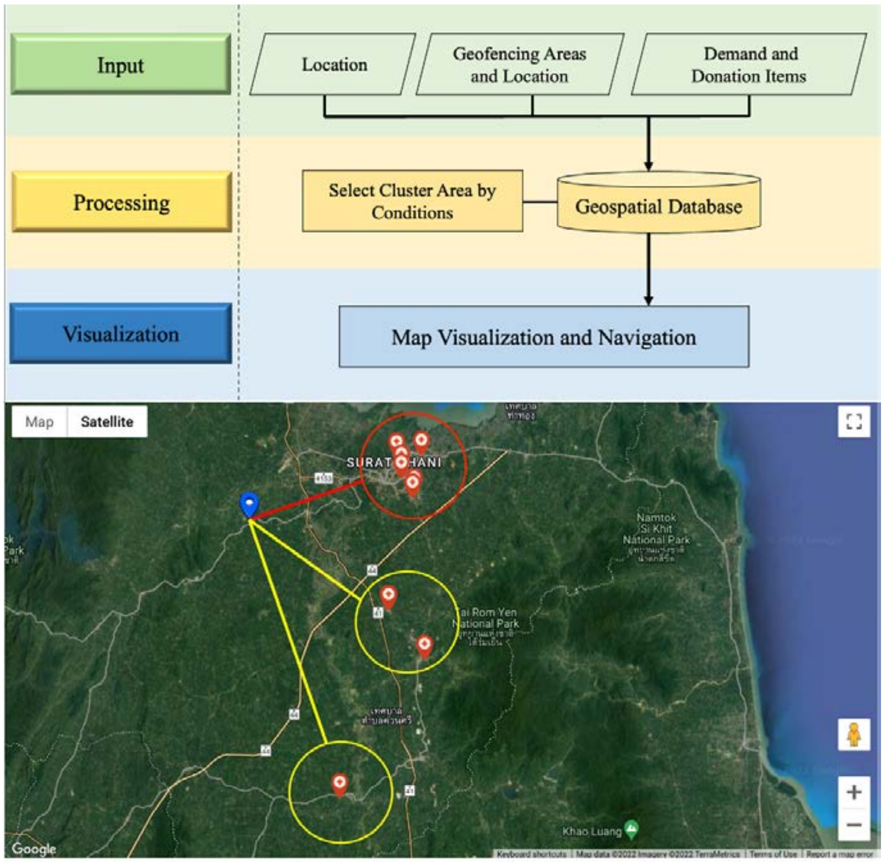


Figure 3. Geofencing methodology

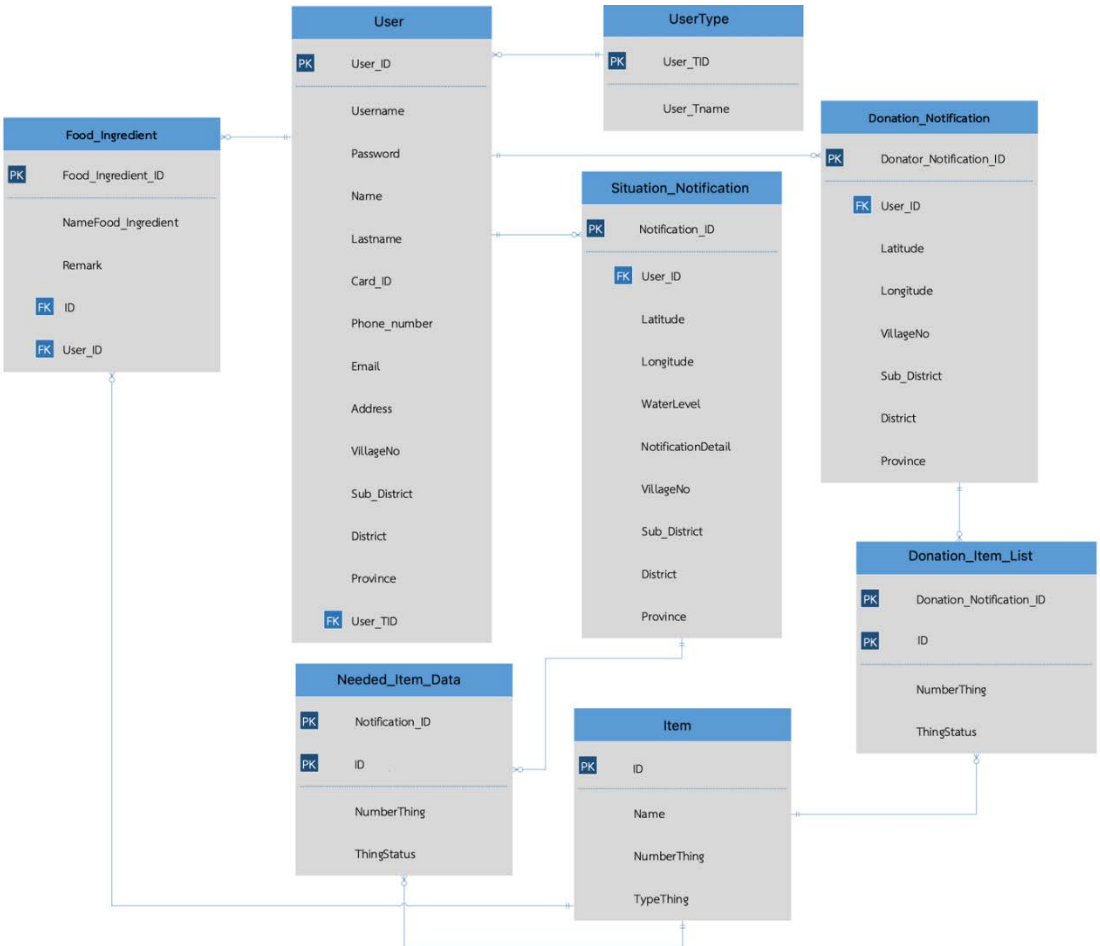


Figure 4. Entity relationship (ER) diagram of the database

4. Results and Discussion

In this section, we present the findings of the system implementation and delve into a comprehensive and rigorous discussion of the results.

4.1. System Implementation

According to application development, it was found that the application was compatible with users' different devices, i.e., various types of mobile devices such as smartphones, tablets, and personal computers. It was compatible with all devices because it was designed as a responsive application, of which capabilities consist of eight modules, to be described as follow. User Authentication: This module was for registration to access the application, with username and password verification for authentication to give information/data of donators and recipients (Figure 5(a) and 5(b)).

Spatial Data Manipulation and Visualization: This module supported three user groups by user type permission. To clarify, "officers" can manipulate data of types of items for victims under the epidemic or disasters. "People" can manipulate data of the number of items they need and the situation in each area. "Donators" can manipulate data of items to be donated. Data manipulation in all 3 user groups is illustrated in Figure 6. Donation Notification: This module visualized geographic coordinates (Latitudes, Longitudes) of donators and recipients in an online map (Figure 7(a) and (b)). They were visualized with red and green markets on map. Red markers referred to victims/people location. Green markers referred to donator locations, of which geographic coordinates are used to navigate officers in charge to get donated items for distributing them to people in each area. Data of receipt and assistance would be updated by officers in charge later. Data update helped each user group to check the implementation status in real time, as in Figure 8(a) to 8(b).

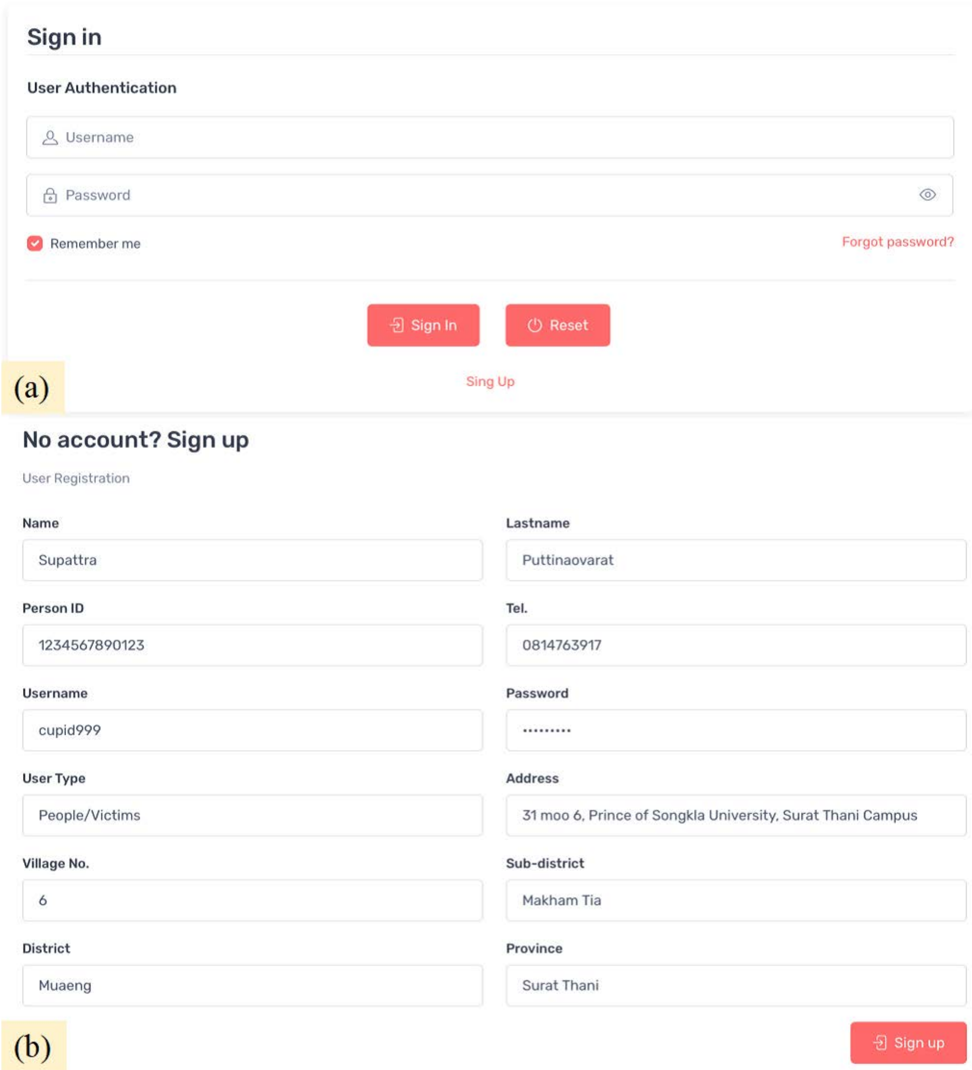


Figure 5. User authentication (a) and user registration (b).

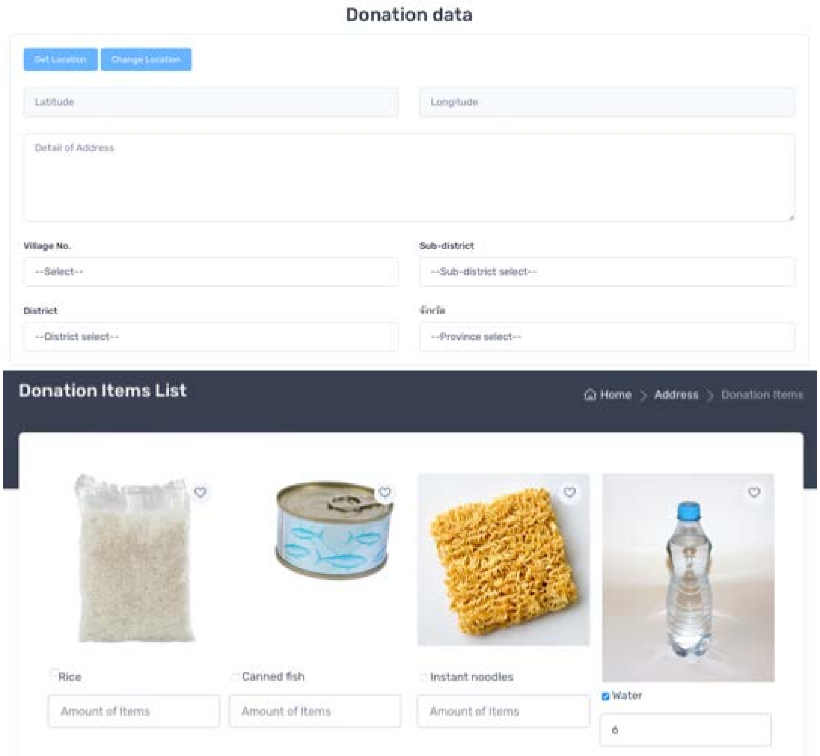


Figure 6. Data Manipulation interface

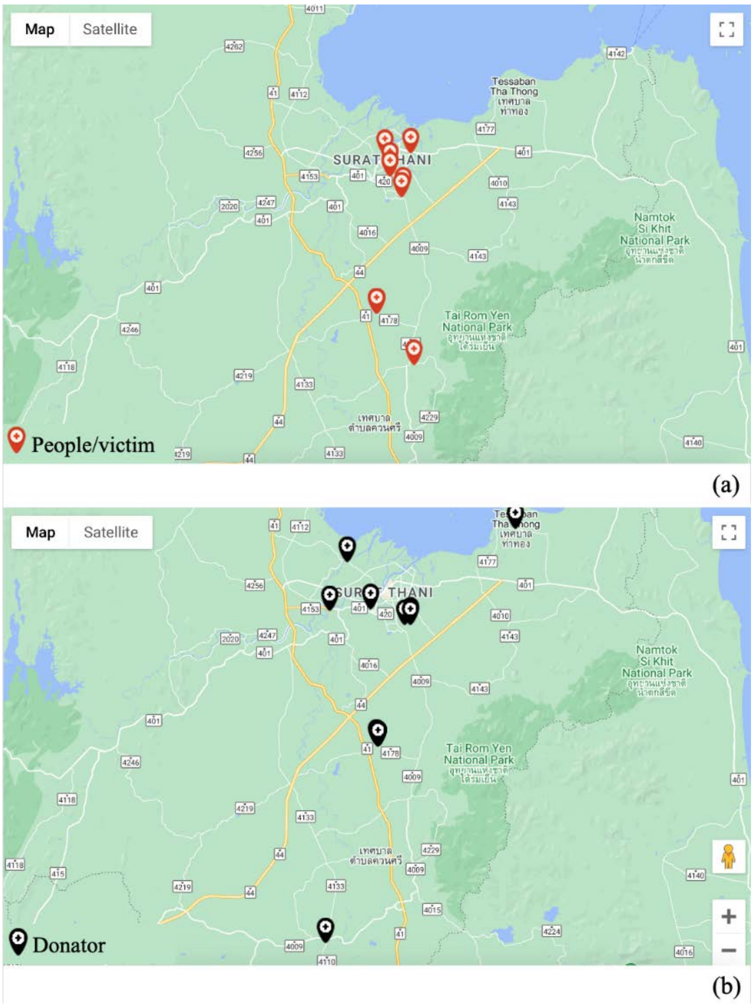
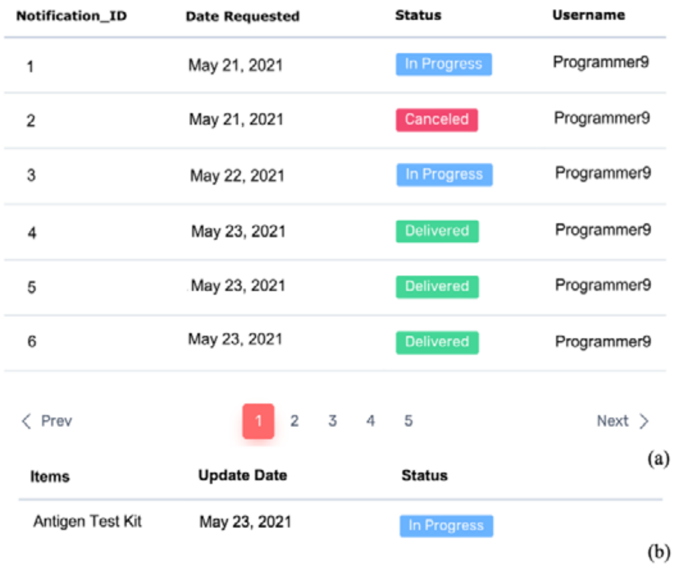


Figure 7. Donators and recipients in online map



Notification_ID	Date Requested	Status	Username
1	May 21, 2021	In Progress	Programmer9
2	May 21, 2021	Canceled	Programmer9
3	May 22, 2021	In Progress	Programmer9
4	May 23, 2021	Delivered	Programmer9
5	May 23, 2021	Delivered	Programmer9
6	May 23, 2021	Delivered	Programmer9

< Prev 1 2 3 4 5 Next >

(a)

Items	Update Date	Status
Antigen Test Kit	May 23, 2021	In Progress

(b)

Figure 8. Status data (a) officer (b) people/victim

The module that could revise the limitations of shortage or excessive items is “Demand Donate Matching.” The function of this module was to process the number of each type of items to be distributed to people. This means the situation that time could verify needs, the number of items, and the number of more donators. When these data were processed, each type of more required items will be acknowledged. This enabled donors to contribute items that matched the requirements of the recipients. And those items could be taken for quick and efficient assistance. The development results are shown in Figure 9. The modules in the introduced application could process data to be acknowledged about needs in accordance with the conditions in terms of distances closest to disaster relief centers and the number of most needed items in each cluster as per fixed radiuses. This is for planning how to take donated items from donators and to provide assistance to the victims. The development results are shown in Figure 10(a) and 10(b). This implies that each cluster contained the different numbers of those who need assistance. There were many of them in some areas while there were only a few in others. So were the numbers of donators. Thus, data visualization by Geofencing or buffer function facilitated an officer in charge to support their decision making on implementation. It could also be used for further development with the navigation module.

The navigation module in this research did not only set shortest distances from fixed disaster relief centers but also used the number of most needed items in each cluster as per fixed radiuses in each cluster. The condition that the application gave precedence to as the first priority is “the number of most needed items,” visualized with red marks while other areas are visualized with yellow marks, as seen in Figure 11. However, using the application to provide assistance for people, officers in charge could make their own decision to choose any particular areas with no need to always follow the suggestions from the application, because each case might contain different effects or severity. Generate Reports as another module of this application could retrieve data stored in the database to issue different types of reports for further management in order to provide assistance for victims under the epidemic or various types of disasters. Those reports could be issued, regarding the situation in each area, about assistance, or item donation in areas in need. The examples of report issuance are depicted in Figure 12(a) and 12(b).

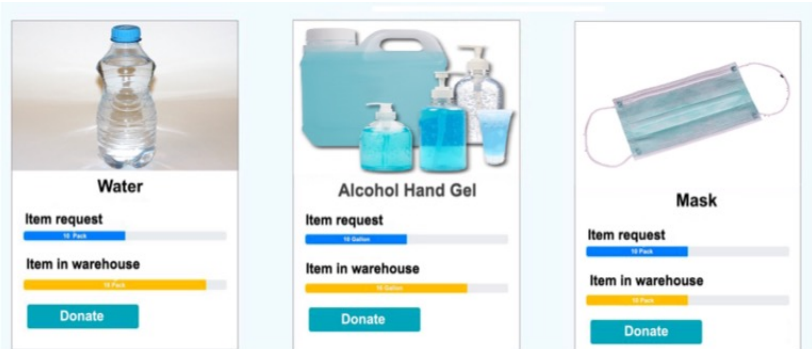
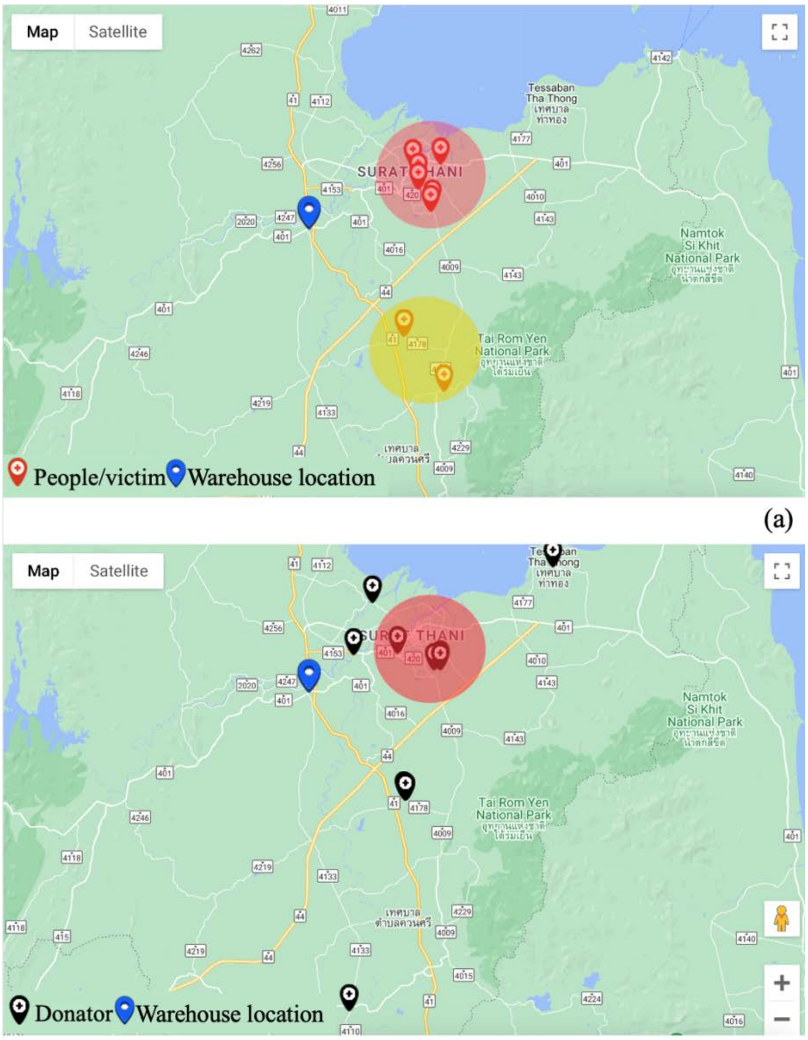


Figure 9. Demand Donate Matching interface



(b)

Figure 10. Geofencing interfaces(a) people/victim location (b) donator location

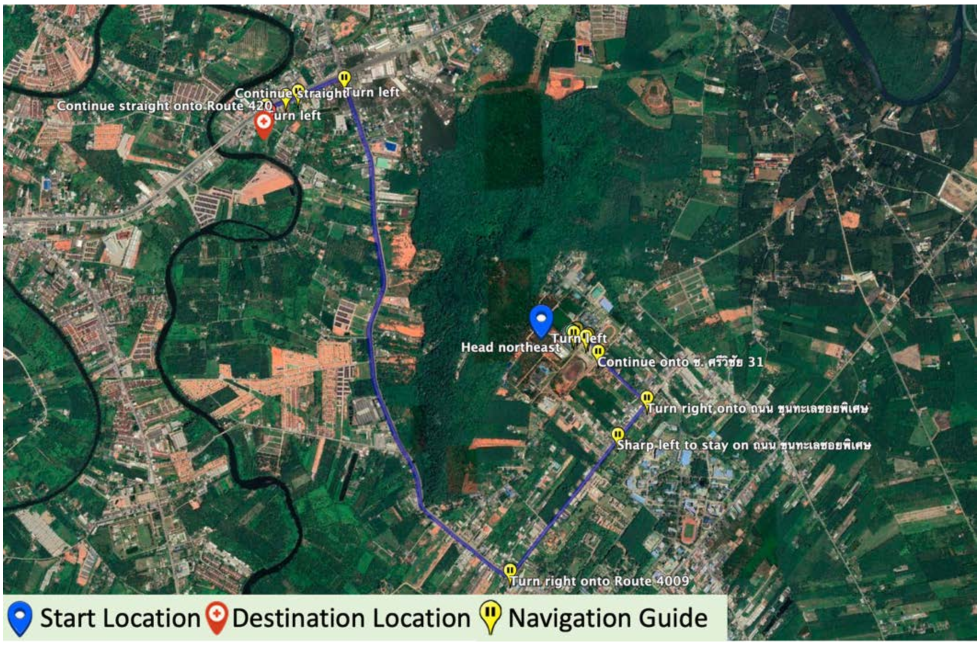


Figure 11. Navigation module

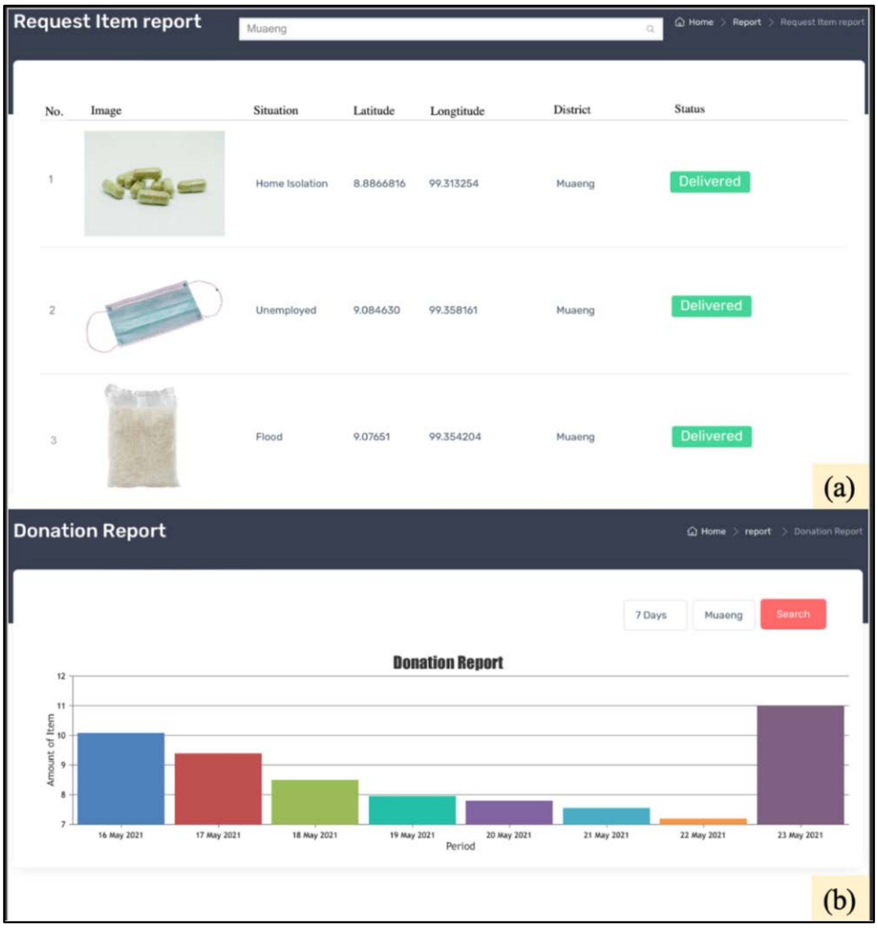


Figure 12. Report example

4.2. Discussion

According to the development of geospatial platform/application for management, in order to get data of the need for donation and receipt by GIS, it was found that the developed application could reduce the limitations and increase implementation efficiency in several issues. To clarify, it supported users, i.e., donators and recipients to notify/inform their needs for donation and receipt. Thus, it could remove the limitations of previous research that did not support notifications from victims in terms of needed items and the number of items [35],[37],[38], resulting in mismatch between donation and actual needs. Additionally, the application in this research could also process data to visualize the number of each type of items for receipt in real time. This feature was not developed in previous research [35],[37],[38]. Moreover, the development of other modules that had not been introduced in previous research were data visualization in terms of needs for donation from donators and needs of recipients in geofencing to visualize the needs in each clusters as per the fixed clusters. Thus, officers in charge could use the application to support their planning and decision making in each area parallel to "Navigation" module that supports navigation to the donators' or recipients' locations.

Furthermore, navigation in this research used not only the condition of distance but also the number of needed items in each cluster. Thus, travel could be planned efficiently and in accordance with the situation in each area. Having this developed application could also facilitate public agencies to retrieve data for necessary budget and resource planning under the epidemic and disasters.

5. Conclusion

The introduced geospatial platform/application has immense potential in managing and providing aid to victims during epidemics and various disasters. It caters to the specific needs of individuals in each affected area, encompassing items, appliances, food, and drugs. Its standout features include real-time data processing and spatial visualization, ensuring timely and informed decisions for relief agencies. Furthermore, the application's data processing capability visualizes the types of required items that precisely match the actual needs, streamlining the donation process and preventing mismatches. The incorporation of Geofencing technology enhances data visualization, allowing for the creation of virtual boundaries and triggering alerts in critical areas.

Navigational features based on distances and item requirements facilitate effective logistics planning, ensuring prompt assistance to those in dire need.

Moreover, the platform issues comprehensive reports that offer valuable insights for management decision-making, identifying areas requiring additional attention or resources. Accessible to three user groups – donators, recipients, and officers in charge – this digital platform allows for swift data manipulation and seamless communication. In conclusion, the geospatial platform/application represents a powerful tool for disaster and epidemic management, enabling timely and targeted assistance to those most in need. Its capabilities in data processing, spatial visualization, Geofencing, and navigation empower relief efforts, fostering more effective aid distribution and support for victims.

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