1. Introduction

Yangon is in the midst of rapid urbanization and development coupled with increasing population concentration in the city; making housing quality and unplanned settlements a major issue in the city.

At the same time, Yangon is also highly likely to experience major earthquake disasters in the future which could result in high fatalities due to the low construction standards. This, with the current growth rate and lack of urban planning controls, will only cause the accumulating disaster risk to worsen in the coming decade.

This paper outlines the current undertakings to consider the existing inadequacies of urban functions in Yangon for emergency response during potential disaster situations. It extends on previous work of Geographical Information System (GIS)-based spatial analyses of urban functions in relation to emergency services on the following aspects:

1) Ambulance and hospital accessibility,
2) Coverage of firefighting services, in consideration with the current traffic conditions.

2. Emergency Services in Yangon

The ambulance services in Yangon city are usually owned and operated by the hospitals themselves, except for the NGOs that also provide such services for the low-income population. These services in Myanmar also usually operate on a case-to-case basis meaning that an ambulance must be requested by calling a particular hospital (usually private) and not through a centralized system like in many developed countries. This hassle has two implications: 1) that people tend to make their own arrangements to arrive to the hospital by themselves, and 2) that this system doesn’t allow for efficient operation during disaster scenarios due to the lack of centralized control. Most ambulances are inter-hospital, and although some Neighborhood Ambulance Services exist, they are often paid services rendering the ambulance unaffordable for the lower-income population who are limited to the restricted coverage of NGO operated services. For our analysis, we considered the non-emergency time connectivity of hospitals in order to address the issue of overflowing patients during disaster scenarios through improving the inter-hospital system and use it for special and/or emergency cases.

Within the Yangon city region, there are 28 fire stations in the 34 townships, excluding those located in the suburbs. The township fire stations are divided into three grades according to their capacity: where an “A” grade fire station comprises 21 firemen; a “B” grade fire station, 10 firemen; and a “C” grade fire station, 8 firemen. For our analysis, we attempted to visualize the extent of reach of the firefighting services over the road network to get an idea of which areas are at risk (unreachable) in case of a fire outbreak, and which areas can be managed with community cooperation.

3. Methodology

For estimating the inter-hospital access during emergencies, an Origin-Destination cost matrix analysis was carried out on the existing road networks to find the current hospital-to-hospital accessibility among General, Private, and NGO hospitals of Yangon. This analysis was carried out using both assumed road speeds based on literature and also acquired bus location GPS data (where available) to reflect the current traffic conditions of Yangon city.

The assumed speeds for the road network were set at: 40km/h for highways, 30km/h for primary roads, 20km/h for secondary roads, and 10km/h for other roads –based on the Yangon traffic congestion study conducted by Kojima, et al. which revealed that the average speed along major roads connecting suburbs with CBD ranged from 20-40km/h. These speeds were also in accordance with the acquired GPS data set averages on the whole and therefore can be regarded as acceptable. The analysis considered which hospitals were reachable under the average travel time across all hospitals (which was 24 mins). This number is used as a starting point to focus on the more accessible hospitals.

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Comparison among different time periods (8 a.m., 12 p.m. and 6 p.m.) also revealed the overall connectivity of the existing hospitals throughout the day (Figure 1-4). Furthermore, the coverage area of the existing Neighborhood Ambulance Services was also examined through a Service Area analysis using the road network data (Figure 5).

The coverage of firefighting services was also examined using Service Area analysis with both assumed road speeds and acquired GPS data (Figure 6-9). The coverage areas were categorized as: within 5 mins, 7 mins, and 10 mins. These break points were determined based on the commonly held assumption that a fire scene can usually be handled if fire services commence water discharge within 7-9 mins from the fire outbreak\(^5\). Considering that on average the preparation time for water discharge from when the firefighters reach the scene takes about 2 mins; the firefighting services must reach the site within 5-7 mins (represented by the above mentioned breakpoints). Comparisons of the same analysis done based on different time periods using the acquired GPS data on the bus networks were also conducted.

4. Results

4.1 Ambulance and Hospital Accessibility

The preliminary analysis filtered out the accessible connections among the hospitals in the network reachable within a 24 minute time frame across the different time periods (Figures 1-3). The differences are particularly noticeable for the two circled hospitals (in Figure 1) across the other time periods as well (Figure 2 and 3). As expected, lesser traffic in the morning hours allow for better accessibility than those during the noon and evening peak hours.
Figure 4 shows the overall connectivity of the hospitals to each other: the circles show hospitals that provide good accessibility on average from the other hospitals across all time periods, while the crosses show those hospitals on the city periphery with bad accessibility, and the triangle signs are the hospitals, namely East General Hospital and Thukhagabar Hospital, that are most impacted by the change in traffic conditions across the time periods.

There are some limitations to the accuracy of these results due to the traffic data being dependent on the bus route network of Yangon. Therefore, the data is fragmented in its coverage of nodes (city-center has the most data) in addition to being limited in the number of data sets for the time periods when the bus is not under operation. Furthermore, there is also discrepancy in that some time periods have more data sets than others causing a variation in accuracy across the time periods.

Nonetheless, the current analysis still provides worthwhile information regarding the connectivity of the hospitals, which can aid in the operation of ambulances both during emergency and non-emergency situations for the inter-hospital transfer of patients. It can also be used as a measure to guide the Transportation Planning of Yangon city to improve the access to emergency facilities.

Facilities that include Neighborhood Ambulance Services were also analyzed as per their coverage area (see Figure 5) with a maximum limit of 12 mins so that the return time total would be within 24 mins in accordance with the previous OD-cost matrix analyses. The darker region represents a break point of 5 mins; and therefore a return time of 10 mins.

From the above figure it is clear that most of the residential neighborhoods of Yangon city, which lie on the peripheries of the city-center, are not coverable by the currently existing Neighborhood Ambulance Services –even with the inclusion of paid ones (offered by fire stations and private hospitals). Furthermore, there is an even lesser area coverage for lower-income people (only NGO ambulance service –square on Figure 5) revealing a complex system of social vulnerability for emergency situations.

4.2 Coverage of Firefighting Services

The preliminary Service Area analysis for firefighting was done with assumed road network speeds as discussed in section 3 (see Figure 6). This was then superimposed with Service Area analysis based on the available GPS data of the bus network for the time periods of 8 a.m. (Figure 7), 12 p.m. (Figure 8), and 6 p.m. (Figure 9). All the figures 6-9 show the extent of reach within 5, 7 and 10 mins. Areas that are reachable within 5 mins are areas which have a higher probability of containing the fire, while areas that fall within the 5-7 mins range will only allow for a 'probable' containment of fire. Areas which fall in the 7-9 mins range are those which, with the help of some community-based firefighting organizations, could keep the fire at bay until the firefighting services arrive; thereby suggesting the need to implement and base such voluntary firefighting in or near these areas.

The analysis also shows the overall lack of coverage of firefighting services (those beyond the shaded region) in the peripheral residential regions of Dagon Seikkan, East Dagon, North Dagon, Mingalardon, Shwe Pyi Tha, Insen, and Hlaing Tha Yar townships. In addition, some pockets of areas that remain outside the reach of surrounding fire stations are also evident.
nearer the city center. Fire occurrences in these areas are highly dangerous and the lack of accessibility needs to be addressed.

For figures 7-9, the overall extent of the coverage area shown in Figure 6 is represented by the striped region in order to show the variation in accessibility caused by the traffic conditions throughout the day. As would be expected, real-time traffic congestion data shrinks the coverage areas on all the three figures considerably compared with the analysis based on assumed road speed.

Among the different time periods, 12 p.m. (Figure 8) shows the highest overall coverage area, while the morning and evening peak hours show decreased reachability in areas along Bayint Naung Road, Insein Road and Pyay Road near the borders of Hlaing and Kamaryut townships (1); along Gan Da Mar Road near the borders of Mayangone and South Okkalapa townships (2); along Kabar Aye Pagoda Road on the border of Yankin township (3); and along Ka Naung Min Thar Gyi Road and Hlaing River Road in Hlaing Tha Yar township (4) (lesser accessibility in evening compared to morning). The morning traffic conditions also show a reduced accessibility along Parami and Pinlon Road going across the Pazundaung Creek into North Dagon township (5). During the day (as per the 12 p.m. data) there is decreased accessibility along the Lower Mingalardon and Insein Road connection (6), as well as along Panthein Road (7) which is also true for mornings.

As discussed in section 4.1, the GPS data acquired is limited to the major roads which are part of the bus route network. Thus, these visuals only provide a rough estimation of the changes in accessibility due to traffic conditions. With the addition of further data sets, a more accurate and realistic estimation can be made for fire response capacity in Yangon.

5. Conclusions and Future Work

This study investigated the existing inadequacies of urban functions in Yangon city for emergency response during potential disaster situations by looking at the spatial relationships between emergency facilities and the current traffic conditions. It revealed considerable shortcomings of the current systems and pointed out potential areas of improvements which can be used to direct future developments in the area through the inclusion of urban planning controls. For example, the hospital connectivity and ambulance accessibility analyses can be used to direct the improvement of road networks and new hospital sites to provide free ambulance services to the surrounding localities. These type of urban planning directives would enable faster emergency response and development that will contribute to the future safety of Yangon.

At the same time, further detailed analysis is required to better
understand the capacity of response under the current conditions. Possible extension on the hospital accessibility analysis would include the consideration of mortality decline rate in relation to the patient transfer speed by the road network and the creation of the most efficient response plans accordingly. Superimposing the slum areas on to the map can also allow for studying the social vulnerability in combination with unequal access to emergency services in developing cities like Yangon, and also see which areas are in need of more free or low-cost ambulance services.

Possible extensions of the work on firefighting services would include: the incorporation of fire-spread cluster analysis in order to measure fire response capacity in relation to the risk involved; considering the optimal fire station cooperation schemes based on the level of fire and differing capacities of the fire stations (grade A, B, and C); and consideration of the best strategic locations to position new fire stations so as to maximize the possible service coverage area.

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