OPTIMIZING FOOD SERVICE ALLOCATION FOR UNIVERSITY OF THE PHILIPPINES (UP) DORMITORIES USING LOCATION-ALLOCATION NETWORK ANALYSIS

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ABSTRACT:

Efficient food service distribution within university dormitories is crucial for student well-being. A survey was executed among the University of the Philippines Diliman (UPD) dormitory residents to ascertain their budget, favoured transportation mode to food outlets, proximity to these establishments, and food category preferences. This study employs location-allocation network analysis to optimize food service allocation across UPD dormitories. An impedance cutoff of 500 meter-distance was used for the search analysis on the food establishments from the UPD dormitories. The objective of this study is to aid UPD administrators in making informed choices regarding food service allocation, enhancing food availability and resident satisfaction. Additionally, the project strives to assist students in selecting lunch destinations. Student population in each dormitory, type of food, and existing food service establishments within UPD dormitories have been collected and analysed. Moreover, this study developed a location-allocation model that considers factors such as dormitory locations, student population, distance, food category, and food service capacity. Two maps were generated showing the allocation of food establishments to each UP dormitory, along with the general pricing of these establishments. This study could enhance food accessibility and satisfaction for UP undergraduate students, serving as an invaluable tool for administrators contributing to optimal allocation knowledge in university settings.

1. INTRODUCTION

1.1 Background

Choosing the optimal and suitable lunchtime meal and location is essential for university students, especially when they aim to sustain their energy levels for the day. The students living in dormitories in a university may have encountered situations where they struggle and find it difficult to come up with ideas in deciding where and what to eat to satisfy their cravings for their lunchtime meal. When faced with this dilemma, the students usually consider several factors to come up with a decision. These factors include the students' budget, target food price range, food preference, distance, and many more.

The study of Abrenilla et al. (2016), examined the food-related behavior of students in Misamis University, Philippines to determine the socioeconomic profile of the students. The study was able to examine the students' way of budgeting, means of obtaining meals, factors for food-buying, and eating patterns. It was found that students rarely create a weekly budget for their expenses. Moreover, the factors that usually affect their dining option and food buying include cleanliness, taste preference, and prices or affordability of foods.

Moreover, Delayco and Biana (2015) conducted a survey that indicated the majority of students enjoy eating out and tend to patronize restaurants that offer meals within their budget constraints. Students typically receive their allowance on a weekly or monthly basis, and this financial factor significantly influences their decision-making process and behaviors related to food (Legaspi et al., 2014). Aligning purchasing behavior with budgeted expenses is crucial for students, as emphasized by Homburg et al. (2010).

With regards to the distribution of food service establishments, Feizizadeh et al. (2023) conducted research on location-allocation methods that employed GIS-MCDA (Geographic Information System-based multi-criteria decision analysis). The methodology aids the stakeholders or officials as well as the individuals to be responsible for decision-making by giving insights into the spatial dynamics of the restaurant sector and identifying prime locations for future growth.

1.2 Objectives and Significance

Limited food accessibility in terms of the selection of food options considering spatial factors, limited scalability and adaptability, and inadequate consideration of student preferences become the issues usually encountered by students deciding on the best option for their lunchtime destination as the school reopened its doors for face-to-face classes in the University of the Philippines Diliman (UPD) Campus last Academic Year 2022-2023. This study intends to address this issue of accessibility to food services through location-allocation network analysis using GIS. It also aims to employ a student-centric and data-driven approach to efficiently assign food services by taking into account several factors/aspects such as price range, capacity, type of food, and proximity by network distance. The results of this study will be able to keep the university officials informed on the current food service infrastructures within UPD dormitories and consider improvements in its services and facilities taking into account various factors such as the location of dormitories, student population in each dormitory, distance between dorm and establishments and food service capacity.

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2. MATERIALS AND METHODS

2.1 Data Collection

The initial phase of data collection involved obtaining profiles of the target variables. UPD Dormitories were designated as facilities, while food establishments were identified as demand points for the location-allocation main processing, with the objective of allocating potential food establishments for different dormitories. The population data of UPD dormitories was collected as weights for the facilities, and data on the capacity and food menu categories of the establishments were gathered for the demand points.

The population data for each dormitory with undergraduate residents was sourced from the UPD Office of Student Housing (OSH). OSH is responsible for handling the application and accommodation process for UPD students who pass their screening process. In the Academic Year 2022-2023, OSH oversaw eleven (11) supervised residence halls for undergraduate students: Acacia, Balay Atleta, Centennial, Ilang-Ilang, Ipil, Kalayaan, Kamia, Molave, Sampaguita, Sanggumay, and Yakal. Table 1 shows the profile of UPD dormitories and its corresponding total population of dormers. Each dormitory has various numbers of total population count. Among these 11 residence halls, it shows that Acacia Residence Hall has the most number of occupants while Sampaguita has the least number of occupants.

Residence Hall	Total Population of Dormers
Acacia	360
Balay Atleta	20
Centennial	307
Ilang-Ilang	72
Ipil	212
Kalayaan	237
Kamia	218
Molave	296
Sampaguita	16
Sanggumay	120
Yakal	228

Table 1. Total population of dormers in each dorm.

To establish the accessibility measures and study area scope, previous research has reviewed the average desirable walking distances for individuals. Yigitcanlar et al. (2007) reported that the maximum distance an individual is willing to walk to a transport terminal ranges from 400 meters (approximately 5 minutes) to 800 meters (10 minutes) for a train station. This information is pertinent in determining the relative walking capacity within a service area. According to the European Commission et al. (2020), people are willing to walk 500 meters to reach the public transport stop in urban settings. In relation to this, in Metro Manila, Ranosa et al. (2017) also found that individuals are willing to walk 400 to 500 meters for public transport facilities.

Furthermore, Yang and Diez-Roux (2012) examined walking distances and durations based on trip purposes and observed that trips to obtain meals have the shortest distances, with the majority walking less than 400 meters. Moreover, Janpathompong, Tontisirin, and Murakami (2022) discovered that the average walking distance during lunchtime ranges from 211.66 to 302.39 meters.

To support this, a survey was conducted among residents of UPD dormitories for a period of three weeks as part of this present study. A total of 250 respondents were surveyed, representing a 95% confidence level and 0.5 maximum variability with ± 6% precision level were drawn from the dormitory population of 2,066 individuals, as determined by the Taro Yamane Formula (Yamane, 1973, as cited in Uakarn, et al., 2021). The findings revealed that the majority of students (81.2%) reported a lunch budget of 250 pesos or less. Additionally, 90.4% indicated a preference for walking to their chosen food establishments, with 54% expressing a willingness to travel less than 100 meters, and a maximum of 500 meters, as stated by 3.6% of the respondents. This trend highlights a general preference for dining options with lesser travel time. With regard to the food category, chicken is most preferred by 60.8% of the dormers. Although the survey showed that the majority of the food choice is chicken, the study has taken into account all of the food category options, which were therefore allocated based on the population of each dorm and the capacity of the food establishments.

To facilitate the survey of food establishments in the area, Every Door platform was utilized for geotagging points of interest (POIs). Every Door is integrated with mapping POIs for Open Street Map (OSM) (Zverik, 2022). Geotagging involved utilizing cell phones capable of detecting Global Navigation Satellite System (GNSS) signals to determine precise positions. By using Every Door application, the investigators were able to pinpoint the location of each relevant establishment as an amenity, which was subsequently uploaded to the OSM database.

To narrow down the extracted POIs from OSM, OSM usernames and food establishment names within the study area were filtered by the investigators. A 5-day on-ground survey identified 150 POIs, which were geotagged and documented in Google Sheets, covering food categories, seating capacity, and pricing. A survey was also administered to UPD dormers via Google Forms to gather data on their background, budgeting, transportation, proximity to lunch spots, and food preferences.

2.2 Data Processing

The data preparation stage involved the preparation of three shapefiles: the UPD Dormitory Points Shapefile with population attribute, the topologically corrected Road Shapefile relevant to the study area, and the Food Establishment Points Shapefile with fields specifying food categories, prices, and seat capacities.

To perform the main processing for optimal food service allocation to the dormitories, the model illustrated by the flowchart in Figure 1 was employed. A geodatabase was created for each food category to organize the data and facilitate network analysis. This included categories such as pork, chicken, beef, seafood, veggies, rice meals, pasta and noodles, pizza and bread, including the respective general pricing of meals in the establishment concerned. Subsequently, a network dataset was generated using the previously prepared road shapefile, with connectivity set to any vertex.

The network analysis commenced by creating a new location-allocation problem with the problem type set to “Maximize Market Share.“ This allocation method involves defining the total number of required facilities with the objective of maximizing the total market share, while considering the allocation of demand weights to the facilities from tge impedance set–proportional to the weight of the facility while

inversely proportional to the distance between the demand point and facility (ESRI, 2021). This problem type is applicable to the present study, which aims to allocate food services to the dormitories, taking into account their population and distance from the demand points. The layer properties for the network analysis are set to – *Accumulation:* length in meters, *Facilities to Choose:* 11 (i.e., the number of dormitories), and *Impedance Cutoff:* 500 c(i.e., cutoff distance from the dormitories to the establishments that can be allocated).

The required facilities were selected as all the UPD residence halls, while the food establishments served as the demand points to be allocated. The UPD Dormitory Points Shapefile was loaded for the facilities class, sorted by the residence hall names, and assigned the following properties – *Name* (i.e. name of the residence halls), *Facility Type*: Required, and *Weight*: Population of the residence halls.

For the demand points, the food establishment points that matched the specified food category were selected from the attribute table. The Food Establishment Points Shapefile was then loaded for the demand points class, enabling loading from "only load selected rows" and sorting based on the category of food establishment. The properties of the demand points were set to – *Name* (i.e. name of the food establishment) and *Weight*: seating capacity of the food service. Once the configuration was complete, the analysis was solved, resulting in lines representing food service allocations to the dormitories. This process was repeated for other food categories, such as chicken, seafood, and other designated establishment categories. By inspecting the attribute table of the line features from the analysis, a summary of the allocated food services in each dormitory was obtained, including the weight, total weighted length, and the total distance from the dormitory to the establishment.

3. RESULTS AND DISCUSSION

The whole project involves a large number of points since the study area covers a 500-meter buffer zone around the facilities (i.e. UPD dormitories) to the demand points (i.e. food establishments). Once the data processing is completed, it is expected to have several maps presenting each of UPD dormitories and the corresponding allocated food establishments categorized by the type of food they offer.

Table 2 displays information on both the total line data and the total located points for each food category (Pork, Chicken, Beef, Seafood, Vegetable, Rice Meals, Pasta/Noodles, and Pizza/Bread). There are a total of 150 food establishments located in the study area. The total line data is not the same as the total located points because the total line data refers to the allocated food establishments per dormitory, while the total located points are the located food establishments out of 150 points that offer the food of the said category. With that, the total line data may or may not exceed the total located points.

A study by Angeles-Agdeppa et. al. (2014) aimed to compare the energy and nutrient intake of Filipino students in school based on nutritionally balanced meals (nutri-meals) and baseline meals they consume. The research focused on various food categories which include Meat, Fish, Vegetable, Fruits, Oil, Cereal, Dairy, Tubers, Legumes, Sugar, and other foods. The findings revealed that students had a higher intake of nutri-meals (e.g., vegetables, fruits, and fish) compared to baseline meals. In addition, it was found that the majority of students

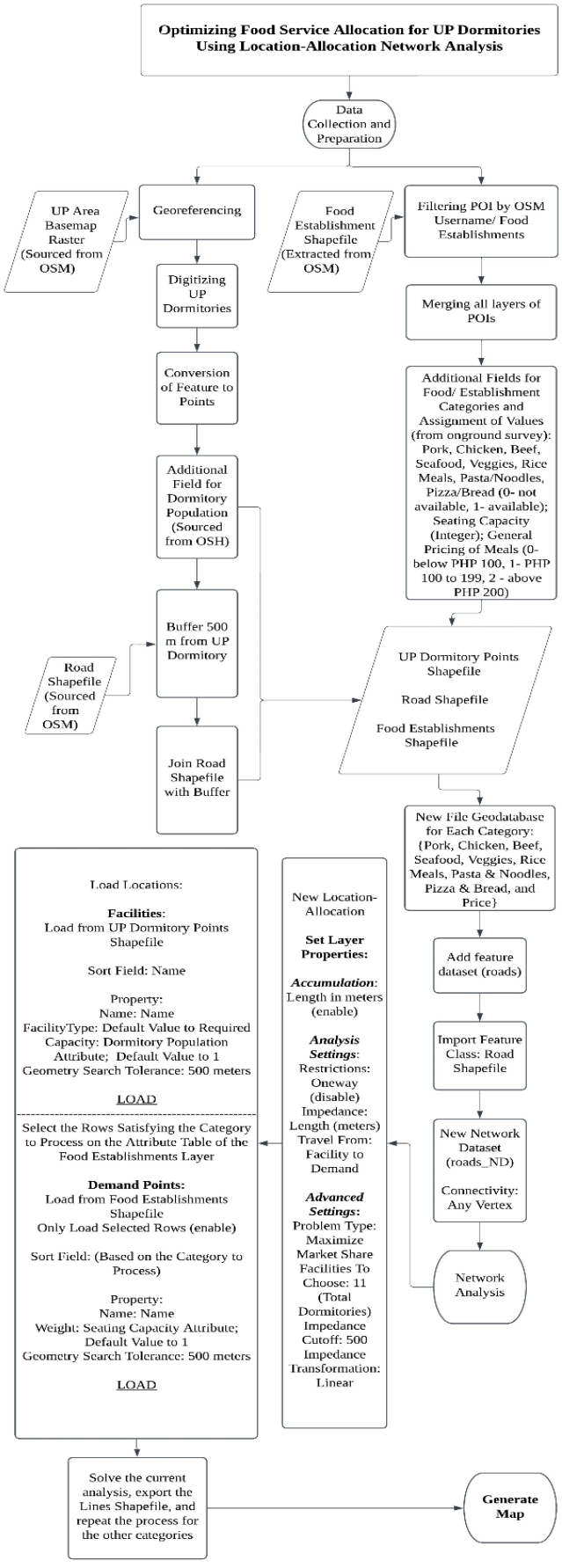

Figure 1. Flowchart of processes.

Category	Total Line Data	Total Located Points
Pork	189	131
Chicken	184	138
Beef	153	118
Seafood	103	101
Vegetables	60	61
Rice Meals	198	138
Pizza/Bread	71	66
Pasta/Noodles	60	67

Table 2. Summary of total line data and located points.

liked both types of meals. Finally, the study suggests that nutri-meals could be a healthier alternative as school meals for Filipino students.

The project used the study of Angeles-Agdeppa et. al. (2014) as an initial basis for their data collection. This project incorporated the food categories used in the said research; the food categories include Pork, Chicken, Beef, and Vegetables while adding other options such as Seafood, Rice Meals, Pizza/Bread, and Pasta/Noodles. These additional options in the food category were added based on the most commonly observed food selections on menus during the data collection from food establishments. Figure 2 provides the statistical summary of the allocated food establishments in the UPD dormitories, a total of 150, with their respective general price range. As observed, Acacia Residence Hall and Balay Atleta both have a total percentage of 6.7% food establishments allocated to them. Centennial Dormitory and Kalayaan Residence Hall both have a total percentage of 8.3% allocated establishments while Ilang-Ilang, Ipil, and Kamia, and Sampaguita Residence Hall have a notably lower percentages of food establishments allocated to them with a total of 0.6%, 1.4%, 0.8%, and 1.1% food establishments, respectively. Sanggumay Residence Hall has 8.6% allocated food establishments, and both Molave and Yakal Residence Halls have 8.1% total allocated food establishments.

In terms of general pricing, there is a total percentage of 41.4% allocated food establishments that offer meals with less than Php 100. Moreover, there are 15.8% allocated food establishments with meals costing less than Php 100 and meals with more than Php 100 but less than Php 200. Meanwhile, there are only 2.2% of food establishments that offer meals that cost more than Php 200 but less than Php 500.

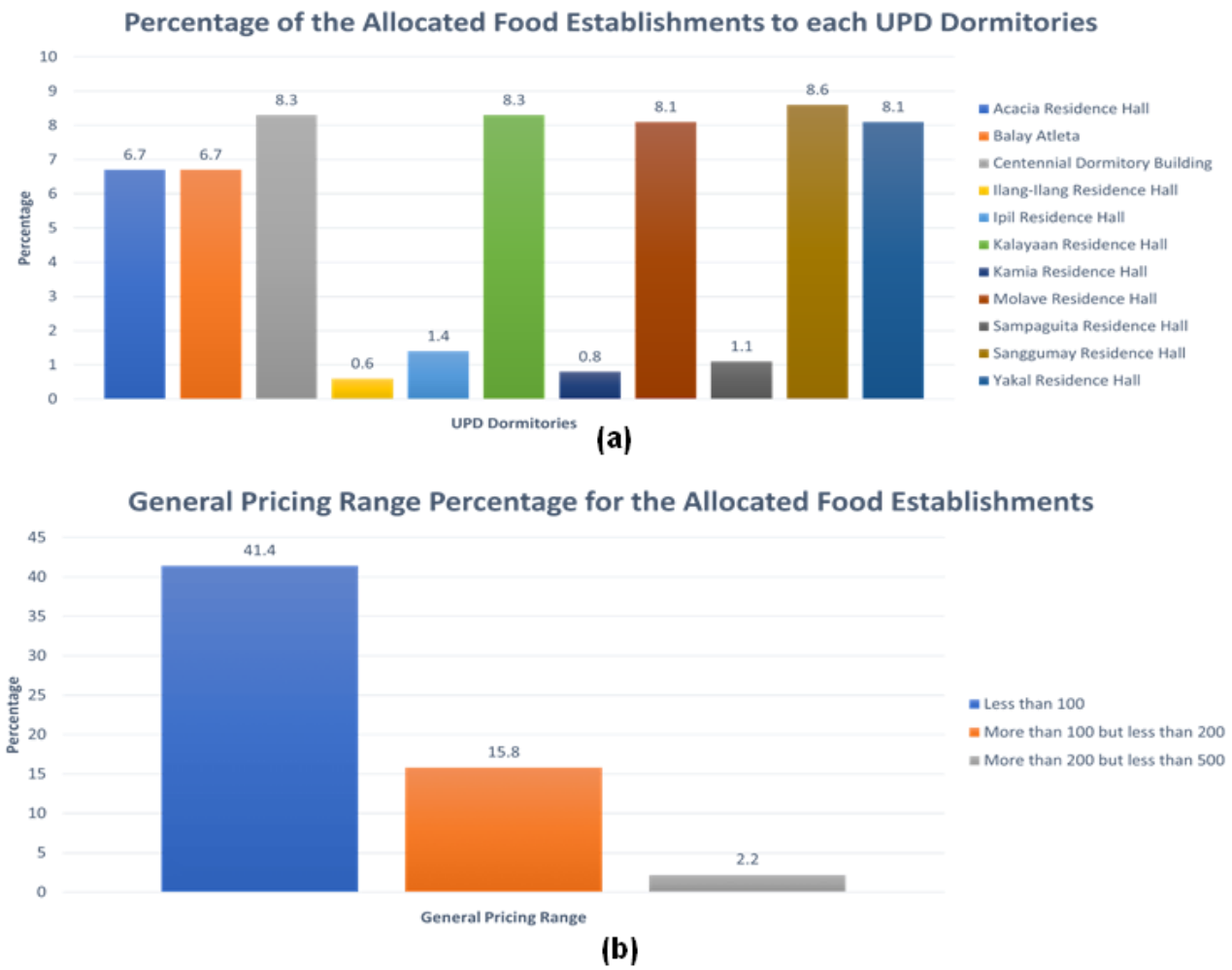

Figure 2. Summary of allocated food establishments in (a) and the general price range preference in (b) of the residents in the UPD dormitories.

The specific details and information about the allocated food establishments and food categories with their respective general prices for each of the UP dormitories can be found in this online repository (http://bit.ly/online_repository).

Figure 3 displays the final map with the food establishments allocated to each dormitory. In this project, Figure 3 shows all the food categories that differ based on colors and thickness of lines. The food categories include Meat, Vegetables, Seafood, Rice Meals, Pasta or Noodles, and Pizza or Bread. With that, the color of the maps corresponds to each of the classified food categories. In the map legend, the located food establishments that offer a specific meal are represented by points, the roads are represented by lines, the multiple lines that connect the dormitories and food establishments indicate allocation, and the facilities or UPD dormitories are marked using an SVG marker set in ArcGIS. The allocated food establishments vary depending on the food category, dormitory location, total dormitory population, and total capacity of the food establishments.

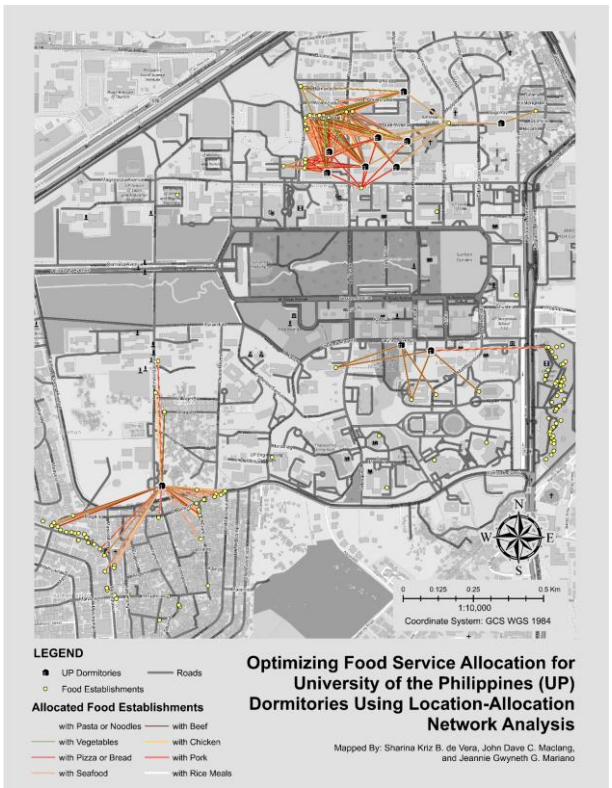

Figure 3. Final map generated for location-allocation of food establishments.

Finally, the last map observed in Figure 4 presents the general pricing information for the allocated food establishments. It displays all the general prices for all the meals that cost less than Php 100, more than Php 100 but less than Php 200, and more than Php 200.

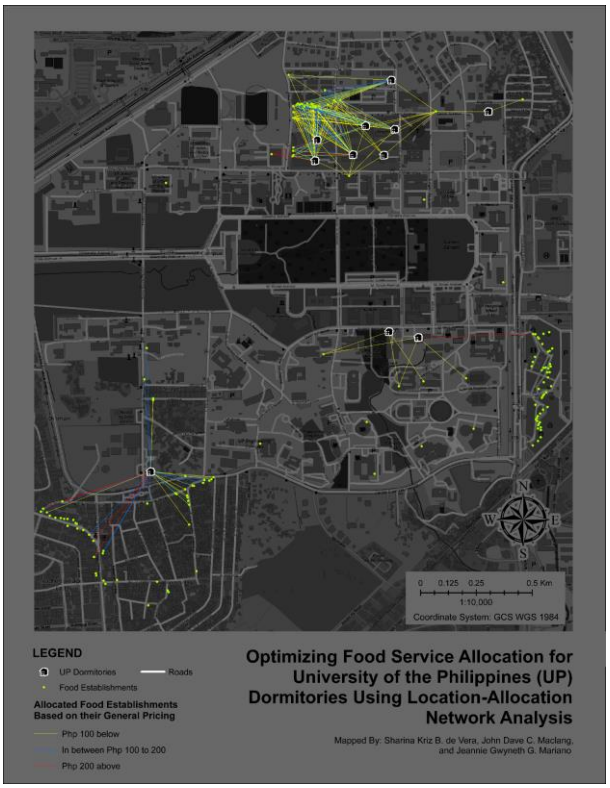

Figure 4. Final map generated for location-allocation of food establishments and their corresponding general prices.

While the results differ in each dorm, it is important to note that all the allocated food establishments fall within the 500 m buffer zone surrounding each of the dormitories. Notably, the network distance was utilized rather than the Euclidean distance in computing for the impedance cutoff. Aside from that, the total population of each dormitory and the total capacity of the food establishments also affected the allocation of demand points to the facilities.

Having a large number of distributed food establishments in a dormitory might indicate that a specific dormitory is located in an area with several food establishments within its buffer zone. In contrast, having a small number of allocated food establishments might imply that the dormitory is located in an area with fewer food establishments in the buffer zone. As observed, the pattern is evident in each dormitory since some have over 30 allocated food establishments while some dormitories have less than 10. Noted in the previous paragraph, the allocation of food establishments is influenced by the total population for each dormitory and the total capacity of the food establishments.

4. CONCLUSION AND RECOMMENDATION

In conclusion, two maps have been generated that showed the allocated food establishments within the 500-meter buffer zone for each of the UPD dormitories in terms of food types and general pricing. This study could be beneficial not only to the undergraduate residents of the UPD dormitories but also to the other undergraduate students residing near those. It could also serve as a basis whenever they wanted to find a place to eat. Since the maps also provide information with regard to the food prices, it could be a big help to the students when they are budgeting as they can estimate the price range of the food. Moreover, the context of food service allocation in university dormitories adds to the body of knowledge on resource allocation optimization in educational settings. By fostering information exchange and encouraging more research in this field, the conclusions and insights generated from this initiative can be shared with other universities and institutions dealing with these comparable challenges.

Utilize the location-allocation network analysis model to develop different scenarios for the optimal placement of food services while taking into consideration several factors such as students' food preferences, travel time, usage of new demand points and facilities, higher buffer zones, and many other various constraints. It is also recommended to conduct location-allocation network analysis in a different area with a wider scope.

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