

Site Suitability Analysis for a New Franchise India Palace Restaurant in Minneapolis and St. Paul, Minnesota, USA Combining GIS Technologies and the Huff Gravity Model

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Abstract

The main objective of this study is to determine a new franchise location in the Twin Cities, Minnesota metropolitan area considering the critical factors that affect restaurant success. It is difficult to select the best-suited location to open a new restaurant. Deciding a suitable spot is the most important task for any business owner because it determines the future of the business, i.e. if it can make a profit. A geographic information system (GIS) is one of the most powerful tools currently utilized to assist in the selection of suitable locations. To conduct analysis, demographic information was obtained from the U.S. Census Bureau for the year 2010. Various analyses were conducted through GIS methods and the Huff Gravity model to determine attractiveness and market potential of trade areas. With the help of software and modern techniques, a suitable location was determined. Some discrepancies were observed between existing locations and areas deemed suitable. This may be due to factors unaccounted for this study such as environment, neighborhood, socio-economic conditions, quality and quantity of food, convenience and visibility. Having a broad understanding of site selection, combined with excellence in execution, is a winning combination for opening a new franchise location.

Introduction

This paper reviews analysis using GIS technologies and the Huff Gravity Model to address the question of where is the best place to open a new franchise India Palace Indian restaurant in the Twin Cities area of Minnesota. Five India Palace restaurants are among the prominent restaurants in the Twin Cities, Minnesota metropolitan area located in Hennepin, Ramsey, and Washington Counties. Initially, India Palace opened their restaurant in Roseville, Minnesota. Then, it expanded in Burnsville, Plymouth, and Eden Prairie.

The Uptown location is the newest and opened in 2015.

The India Palace Restaurant has opened branches in Indianapolis, IN; Dallas, TX; San Antonio, TX; Provo, UT; Fargo, ND, and other locations. It offers North Indian and South Indian food with a very unique taste. The owner and management team are devoted to make their customers' visit a truly memorable and remarkable experience with a variety of flavors. Various criteria should be considered when opening a new restaurant. Minimum standards for any given location would depend on different

circumstances including population and density of surrounding area, demographics, income level of residents, average amount of car and foot traffic, proximity to mass transit, businesses, local landmarks, and attractions, zoning requirements, utilities assessment, accessibility, food varieties, popularity of restaurant, number of nearby competitors, center size for center of gravity technique, etc. Further details include payment plan (e.g., credit cards, cash, check), food plan (e.g., vegan, gluten-free, kid's menu), establishment features (e.g., handicap, accessible, smoking), and parking (e.g., garage, free).

Site selection has a huge impact on almost every facet of the design and construction process, since it handles the interests of the users and the community. It should be executed precisely because the success or failure of a restaurant depends on its location to a great extent. All these processes become possible by administering new GIS technologies.

Background

Franchising proposes opportunities for individuals and business firms who want to expand the number of distribution outlets carrying their products and services (Khan, 1992), and it is becoming an important strategy in the global markets for business growth, creation of jobs and economic development. Restaurateurs are in competition and thinking hard about where and how to expand their business (Steintrager, 2001). The statistics seem to suggest that franchising a restaurant has extensive advantages that essentially increase the chance of success of a franchisee over an independent operator (Swerdlow, 1993). Ghosh and Craig (1983) explained that distribution and composition of population are

fundamental factors influencing store volume and are changing over time. Therefore, franchisors should take into account the dynamic nature of the business environment. In addition, changing demographics induce greater uncertainty in how to optimally meet consumer needs and wants (Ingene and Lusch, 1980).

Indian food is both exciting and intimidating with its exotic ingredients, unfamiliar dishes, and tongue-tingling flavors. A wide variety of flavors can attract anyone from children to elderly people and make them satisfied. Indian restaurants are attracted to open franchises in different cities, either in the same state or in different states for consistent service and profit. Franchises should maintain recognition of the parent restaurant, franchisor's trademark, service mark, trade name, and logotype. For a good response from the customer, quality customer service, ambience, ethics, background music, cleanliness, language proficiency, etc. are very important.

Site Selection

Finding the right location for a restaurant takes time and hard work (Rex and Walls, 2000). A key challenge facing every franchisor today is how to quickly identify factors that determine a successful franchise location (Blake, 1993). Good locations allow ready access, attract large numbers of customers, and increase potential sales.

According to Nelson (1958) and Great Wall Supermarket's experience, location depends upon various factors, for instance, population density, reputation, accessibility to resident population, competitor locations, land use, physical desirability, appearance, size, shape, neighborhood, other amenities, roads, and transportation accessibility.

Acquisition of Data

For the purpose of this project, Hennepin and Ramsey counties represented the study area. Restaurant information and existing site addresses were acquired from the restaurants' websites. Restaurant location helps to determine the size of site, convenience, and visibility. Census tract data for 2010 and other required data sets were obtained from the U.S. Census Bureau and the U.S. Census Bureau's American Fact Finder website. A tract is a relatively small, stable geographic area and a permanent statistical subdivision of a county designed to be a comparatively consistent unit in regards to population characteristics, economic status, and living conditions. Census tracts generally have a population size between 1200 and 8000 people with an optimum size of 4,000 (U.S. Census Bureau, n.d.).

Methods

Software and Equipment Used

GIS makes it possible to store a vast amount of spatial data in digital form and perform statistical analysis, modeling, and visual display of geographic data. GIS software and additional technologies were used to conduct the study. The following software and applications were used: ArcGIS 10.5, PythonWin, Google Maps, Google Earth Pro, and Microsoft Excel. These tools were used for data collection, transformation, manipulation, analysis, and presentation.

Data Analysis

The restaurant location records were edited and imported into Microsoft Excel, and latitude and longitude fields were also added. Google Earth Pro was used to

extract latitude and longitude information identified in units of degrees minutes seconds (DMS), which were converted into coordinate values in meters. The final result was a point shapefile representing the precise geographic location of each restaurant. The census data coordinate system was set to the World Geodetic System 1984 (Figure 1).

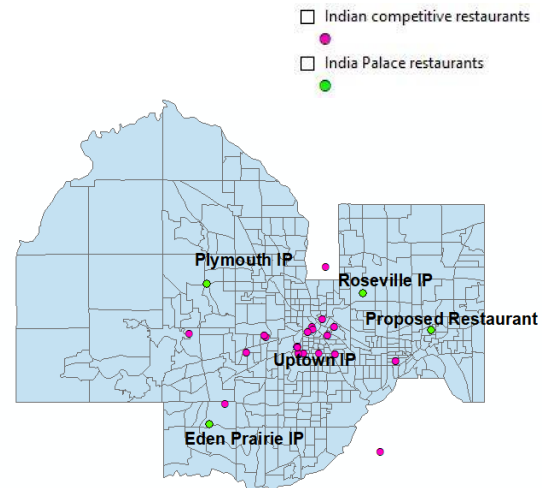


Figure 1. India Palace (IP) and other competitive restaurants in Hennepin and Ramsey Counties.

Businesses want to open in areas where there is consumer demand and the consumer is willing to spend. To determine these areas, demographics provide an understanding of the potential customer. Various demographic criteria were used to evaluate site suitability (Table 1).

In order to perform suitability analysis, demographic census data were converted into geodemographic data through a join operation. Each of the demographic datasets were joined to a Minnesota census tract shapefile through a common attribute and then exported as a new shapefile that contained the required geodemographic census information. Then, the criteria in Table 1 were used to query census tract polygons. Separate polygon layers of tracts meeting each

criteria were created. The variables in vector format were transformed into raster through Point to Raster and Polygon to Raster tools (Appendix A).

Table 1. Criteria used to determine suitable sites and their assigned weight for weighted sum analysis.

Criteria	Weight
Median household income greater than \$60,000	10%
Median age greater than 25	5%
Existing India Palace restaurants	20 %
Location is at least two miles away from competitors	20%
Density of total population is greater than 3000 per square kilometer	10%
Density of Asian population is greater than 200 per square kilometer	5%
Total population is greater than 3500 per tract	5%
Total Asian population is greater than 400 per tract	5%
Nearest main road is within 500 feet	5%
Nearest bus stop is within 1500 feet	5%
Land is zoned for retail and other commercial	
Agricultural land	2.5%
Mixed use commercial land	2.5%
Retail and other commercial area	2.5%
Undeveloped area	2.5%

The Euclidean Distance tool was applied for roads, bus stops, and competitive restaurants (Appendix B). For the distance to nearest road variable, the Raster Calculator was used to derive the areas within 500 meters of a road. A similar process was used to identify areas meeting the distance to bus stops and competitor criteria.

Since there were multiple datasets with different geodemographic information, data need to be reclassified. Reclassification is important in site selection analysis because it is used to simplify the interpretation of raster data by changing a single input value into a new output value (Esri, n.d.a). Cell values of 1 (meets criterion) and 0 (does not meet criterion) were used.

Weighted Sum Analysis

When performing site selection analysis, GIS software can rate the best sites. Site selection analysis can be done with either vector or raster data, but one of the most widely used types of site selection, weighted site selection, uses raster data. Weighted site selection is used to find the rankings of suitability for cells in a raster dataset or to rank more or less important sites (Esri, n.d.a). Weights are assigned as percentages to input rasters that must add up to 100%. The analysis overlays several rasters, multiplies each by their given weight, and results are added together to create a site suitability output raster. Site selection using raster data is a powerful tool and used to determine areas that may be valuable to survey (Niemuth, 2013).

Raster data are well suited for representing data that changes continuously across a landscape. Feature details represented by a raster are often dependent on cell size. Cell size should be chosen in such a way that analyses can perform efficiently. For this project, a cell size of 100 by 100 meters was chosen.

Weighted sum analysis was used to identify the most suitable census tracts in the study area. Rasters representing the variables were combined with their weights (Table 1) based on their importance to determine final suitability.

Resulting cell values were reclassified into equal intervals with the following five suitability categories: not applicable, probably applicable, good, better, and best. Weighted sum analysis determined that the best location would lie in the red area of Figure 2. Census tract areas in orange were considered as a better place to open a restaurant. Similarly, areas that lay in yellow and light green colors were considered good and probably applicable areas, whereas dark green

colored census tract areas were considered not applicable as they met very few criteria (Figure 2).

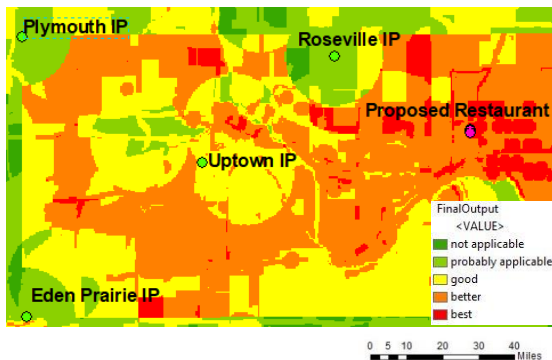


Figure 2. Weighted sum analysis of potential Indian restaurant market areas. The best areas (red) represent higher market potential.

Further analyses, such as reviewing bus stop facilities and near-by competitive restaurants, were done in the best (red) areas, and a proposed restaurant location was identified in the eastern portion of St. Paul as shown in Figure 2.

Huff Model for Site Evaluation

The Huff Model was used to evaluate the proposed and existing locations. The model was introduced by David Huff in 1963 for decision-making related to total sales flow and choosing the best options for site selection (Huff, 1963). The hypothesis is that gravity models can analytically evaluate the impact of location on the success of restaurants, determine market potential (Herrington and Lu, 2016), and depict probability-based markets or represent economic impact. The Huff Gravity model assumes an analogy between human behavior and Newtonian gravity laws and is based on the basic gravity formula, in which movement of individuals between points is inversely proportional to the distance separating them. This method was applied by Converse (1949) and Reilly (1931) to

analyze business and market areas.

In this project, distances were calculated between India Palace restaurant locations (existing and proposed) and each census tract centroid using the Point Distance tool. Attractiveness was calculated using restaurant size and distance, and then probabilities for each restaurant's market share were measured.

To conduct the Huff model, layers are required to have the same coordinate system. The Project tool was used to change the dataset from a geographic coordinate system in decimal degrees (DD, angular units) to a suitable projected coordinate system in linear units (meters). In this project, the projected coordinate system used was the North American Datum of 1983 Universal Transverse Mercator Zone 15N. A step by step calculation of the Huff Model was conducted and illustrated with visual display. Existing restaurant locations and census tract data played a vital role in the analysis.

Step 1. Distance Calculation from Each Restaurant to Each Census Tract

Figure 3 shows the census tract centroids, which were calculated using the Calculate Geometry tool within the attribute table of the feature class. In the attribute table of the census tracts, two fields named CentroidX and CentroidY were added. With Calculate Geometry, CentroidX and CentroidY were populated with x and y coordinates of each centroid respectively. Tabular data that contained geographic locations in the form of x, y coordinates was added to ArcMap through the Add XY data tool. These were added as events and converted to a shapefile in order to be viewed and analyzed in ArcMap.

Then, distances were calculated from all India Palace restaurant locations

to each census tract centroid. For this, the Point Distance tool was used. This tool creates a table with distances between two sets of points.

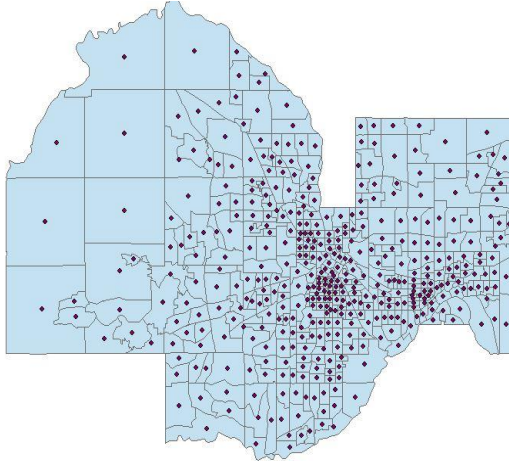


Figure 3. Centroids of each census tract.

Step 2. Incorporate Attractiveness with Restaurant Size and Distance

Attractiveness was determined based on the size of the restaurant and the distance from the restaurant to each census tract. Restaurant size was measured using the ruler tool in Google Earth Pro (Table 2).

Table 2. India Palace restaurants with size.

1. Roseville India Palace: 423.78 sq. meters
2. Plymouth India Palace: 280.84 sq. meters
3. Uptown India Palace: 327.43 sq. meters
4. Eden Prairie India Palace: 275.52 sq. meters
5. Proposed new India Palace restaurant: 450.51 sq. meters

Then, attractiveness of each restaurant for each census tract was calculated as the size of the restaurant location divided by the distance squared (Figure 4). When attractiveness scores were plotted on a series of maps, it could be seen which restaurant most attracted each census tract (Appendix C).

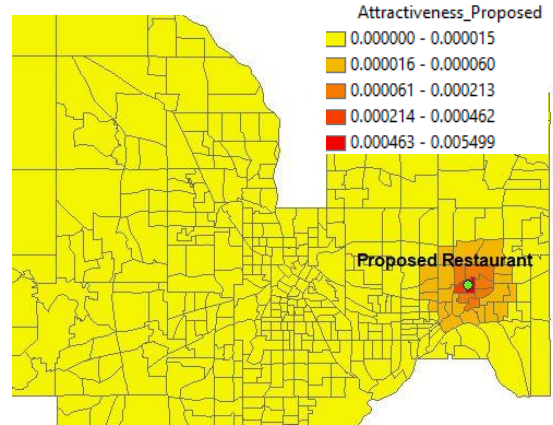


Figure 4. Attractiveness of proposed restaurant.

Step 3. Measurement of Probabilities for Each Restaurant's Market Share

According to the GIS Geography (2018) website, the formula for the Huff Gravity Model is as follows:

$$P_{ij} = \frac{S_j / T_{ij}^\lambda}{\sum_{j=1}^n S_j / T_{ij}^\lambda}$$

Where,

P_{ij} : Probability of a consumer at point i travelling to location j

S_j : Size of location

T_{ij} : Travel time (or distance) from consumer at point i to travel to location j

According to the above formula, the attractiveness score for each restaurant location is divided by total attractiveness, which results in the probabilities for each location's market share. A restaurant captures a large share of the market in nearby areas.

With the help of the Huff model, gravity-based probabilities for each origin location were calculated, and areas of high and low sales potential were forecasted; this information could guide new restaurant location placement or be used for advertising initiatives in the

future (Esri, n.d.b) (Appendix D).

Results

The final suitability map shows most competitive Indian restaurants met the required criteria. The India Palace restaurant at the Uptown location and the proposed franchise restaurant location met most of the criteria, and are located in red areas; therefore, they are considered to have the best suitability. The Eden Prairie location met fewer criteria so their suitability is considered good, whereas the Roseville and the Plymouth locations met very few criteria in comparison to other locations, so their locations were deemed probably applicable.

The Huff Model also showed the proposed restaurant would expect to capture 75% to 100% of the market share in nearby tracts (Figure 5). In addition, the proposed restaurant is located in a census tract area where Asian population is 1355 out of a total population of 4258.

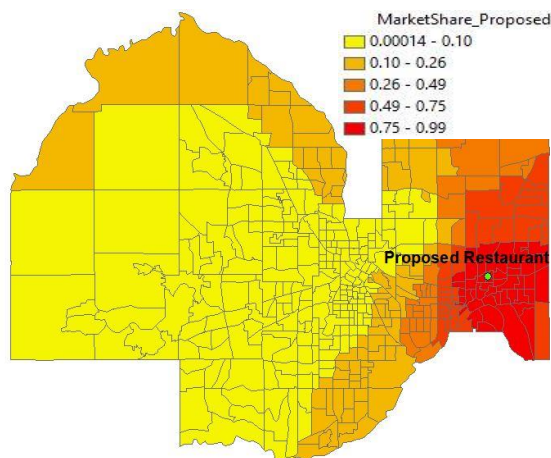


Figure 5. Market share potential of proposed restaurant.

Roseville is the parent restaurant among all India Palaces and has gained popularity over time. According to India Palace owners, it has the highest sales volume and number of employees; however, in this study, the suitability

category of its location was only “probably applicable” (Figure 2). This suggests that a restaurant location’s success depends on numerous factors in addition to the major criteria. Various factors that were not considered requirements for this suitability analyses may also play a vital role in site selection. For instance, the location may succeed due to food quality with reasonable prices, good customer service, ambience, ethics, background music, cleanliness, parking and restaurant space, type of neighborhood, lifestyle, market structure, proximity to mass transit area businesses, topography, physical and psychological barriers, local landmarks and attractions, outdoor seating, visibility, popularity of parent restaurant while opening the franchise restaurant, and other socio-economic factors.

Accessibility of Proposed Location

In this project, distance to nearest bus stops and competitive restaurants were researched further with the help of Google Maps, Google Earth Pro, and Python coding to evaluate the proposed location for a new restaurant.

The Python script created takes the input location of the restaurant as X and Y coordinates in meters. The location of the proposed restaurant location was - 10360869.953 meters (X) and 5617722.511 meters (Y), and the projected coordinate system was WGS 1984 Web Mercator Auxiliary Sphere. Based on the location of the restaurant, the nearest bus stops were identified by applying the Pythagorean Theorem. The result found that the nearest bus stop is located at Payne Avenue and Geranium Avenue and is 41.06 meters from the restaurant. This would be the most convenient bus stop for customers. Similarly, other near-by bus

stops were determined to be within walking distance, defined as within one mile of the restaurant (Table 3).

Table 3. Ten nearest bus stops to proposed restaurant.

1. Bus Stop 1 at Payne Avenue and Geranium Avenue is 41 meters away.
2. Bus Stop 2 at Payne Ave and Lawson Ave is 591.44 meters away.
3. Bus Stop 3 at Arcade St and York Ave is 815.27 meters away.
4. Bus Stop 4 at Maryland Ave and Arcade St is 826.85 meters away.
5. Bus Stop 5 at Arcade St and Maryland Ave is 864.77 meters away.
6. Bus Stop 6 at Payne Ave and Case Ave is 870.35 meters away.
7. Bus Stop 7 at Payne Ave and Case Ave is 899.54 meters away.
8. Bus Stop 8 at Payne Ave and York Ave is 1149.71 meters away.
9. Bus Stop 9 at Arkwright St and Maryland Ave is 1201.03 meters away.
10. Bus Stop 10 at Arkwright St and Case Ave is 1475.53 meters away.

Similarly, nearby competitive restaurants were also determined. The Pythagorean Theorem was applied to find the distance to Indian restaurants and other popular American restaurants. The result determined that there are three competitive Indian restaurants within five miles of the proposed location. These restaurants are Indian Masala, Taste of India and India House. There were two other possible competitive American restaurants nearby i.e. Cook and Magnolias Restaurant. The result showed the nearest competitive restaurant was Cook, which was 118.46 meters away from the proposed restaurant and located at 1124 Payne Ave in St Paul. Similarly, four other nearby competitive restaurants were found (Table 4).

Discussion

Most retailers cannot rely solely on the Huff Gravity model to make million dollar

Table 4. Competitive restaurants near the proposed restaurant in ascending order based on distance.

1. Competitive Restaurant 1: 'Cook' at 1124 Payne Ave, St Paul, MN 55130 is 118 meters away.
2. Competitive Restaurant 2: 'Indian Masala' at 27 Century Ave N, Maplewood, MN 55119 is 295.37 meters away.
3. Competitive Restaurant 3: 'Taste of India' at 1745 Cope Ave E, St Paul, MN 55109 is 7585.99 meters away.
4. Competitive Restaurant 4: 'India House' at 758 Grand Ave, St Paul, MN 55105 is 8561.32 meters away.
5. Competitive Restaurant 5: 'Magnolias Restaurant' at 1081 Payne Ave, St Paul, MN 55130 is 11157.49 meters away.

site selection decisions. As a gravity model, the Huff Model depends heavily on distance and size of location. It is required to use correct data for analysis and accurate representation of findings. There may have been mistakes in obtaining information, and data may contain errors including misspellings, invalid, and irrelevant data.

It is necessary to understand the accuracy of data being used and limitations that exist. To minimize inaccuracy, the Huff model was combined with GIS techniques to make the right decision. Since GIS is proven to be an effective tool for integrating, managing, storing, displaying, mapping, querying, and spatially analyzing data, it provides an effective means for identifying empirical patterns and producing visual displays of data, which is an effective method of communication between system and user.

Conclusion

The results showed that there were many suitable locations to open a new restaurant; however, it is necessary to check which locations have the most sales potential. After considering different

criteria, it was concluded that a proposed restaurant can be opened in the eastern portion of St. Paul without any overlap in competition with other India Palace restaurants and other competitive restaurants (Figure 6).

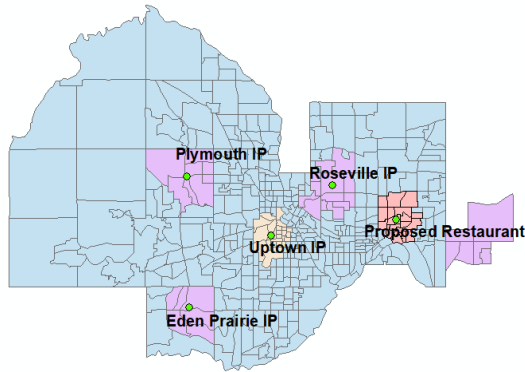


Figure 6. Existing India Palace restaurants and the proposed India Palace. Shaded areas are the tracts where the centroid is within 2 miles of the restaurant.

Some discrepancies were observed between successful existing locations and areas deemed suitable, which suggests that there were suitability criteria that were unaccounted for. Various minor criteria impact suitability indirectly. Therefore, while doing future analysis, all criteria, either major or minor should be taken into consideration so that a new franchise location would have higher rates of success than other start-up businesses. It may be easier for new franchises to succeed compared to their predecessors since their parent restaurant already established reputation and image, proven management, and work practices.

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Appendix A. Census tracts representing areas that matched each selected criteria (areas with value of 1) along with existed restaurant locations in raster form. Green dots are existing India Palace restaurants and the new proposed location.

Population Greater than or Equal to 3500.

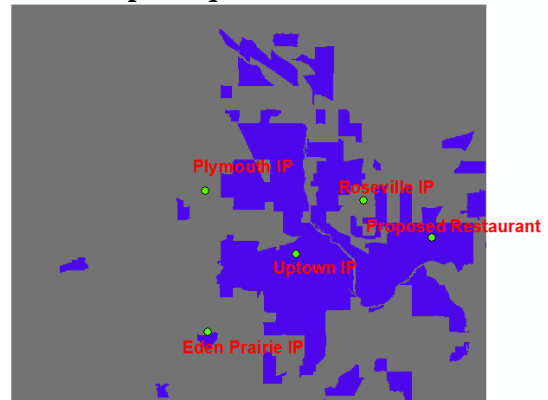


RasterPopulation >= 3500

Value



Population Density Greater than 3000 per Square Kilometer

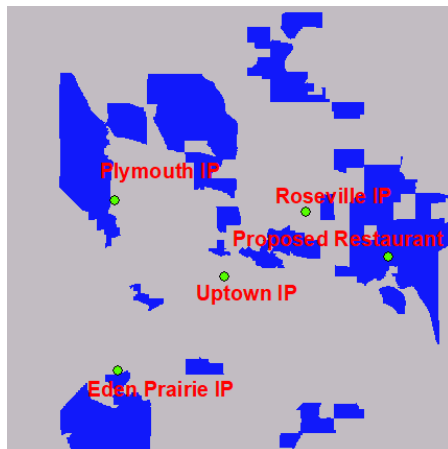


☒ RasterPopDensity

Value



Asian Population Greater than or Equal to 400



☒ RasterAsian >= 400

Value



Asian Population Densnity Greater than or Equal to 200 per Square Kilometer

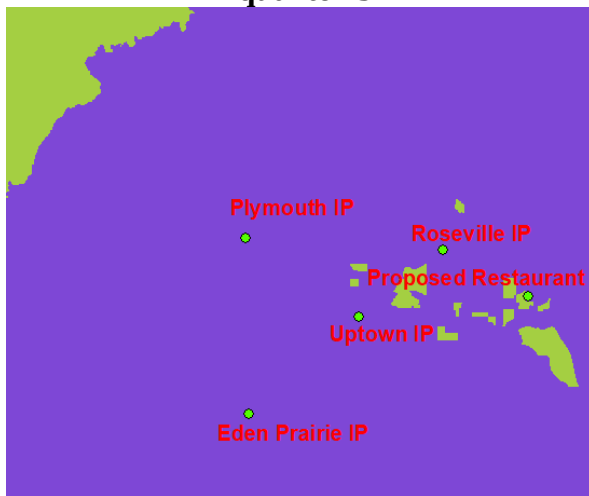


☒ RasterAsianDensity >= 200

Value



Median Age Greater than or Equal to 25



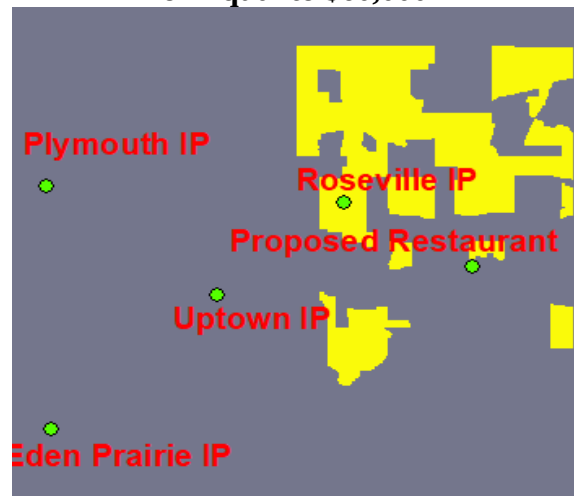
RasterMedianAge >= 25

Value

0

1

Median Household Income Greater than or Equal to \$60,000



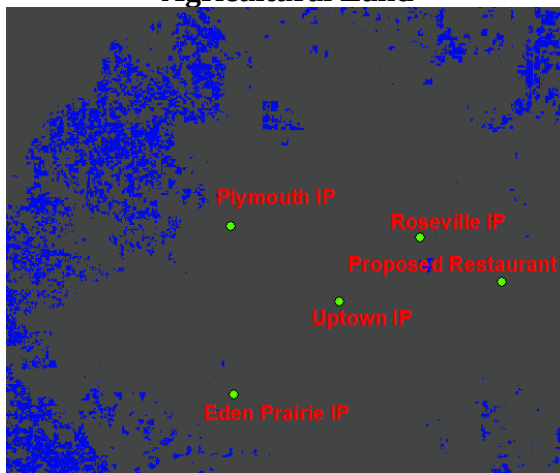
RasterRamseyMHI >= 60000

Value

0

1

Agricultural Land



☒ RasterAgricultural

Value

0

1

Mixed Use Commercial Land



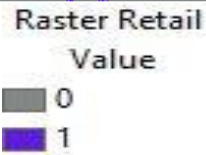
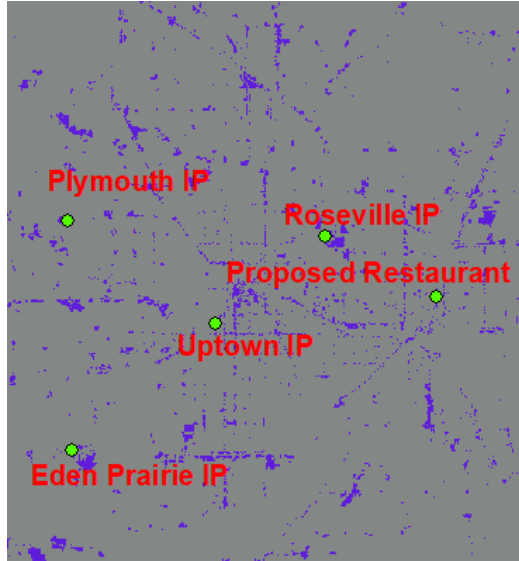
☒ RasterMixUseCommercial

Value

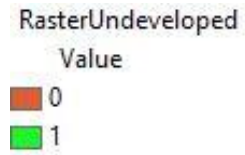
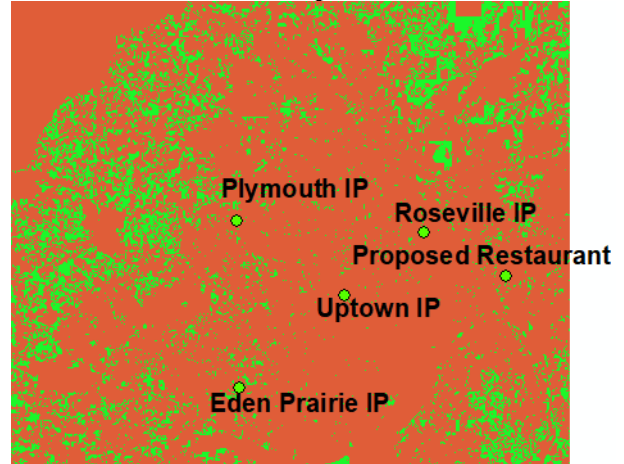
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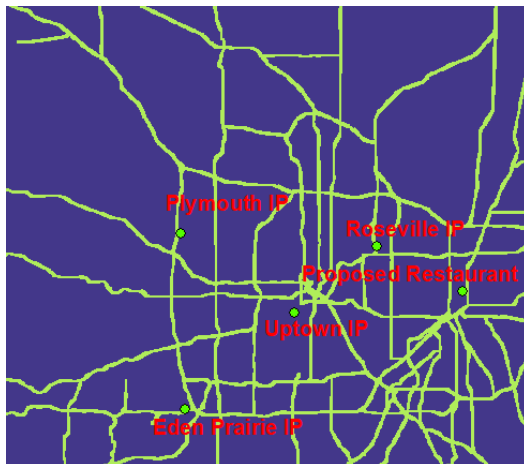
Retail and Other Commercial Area



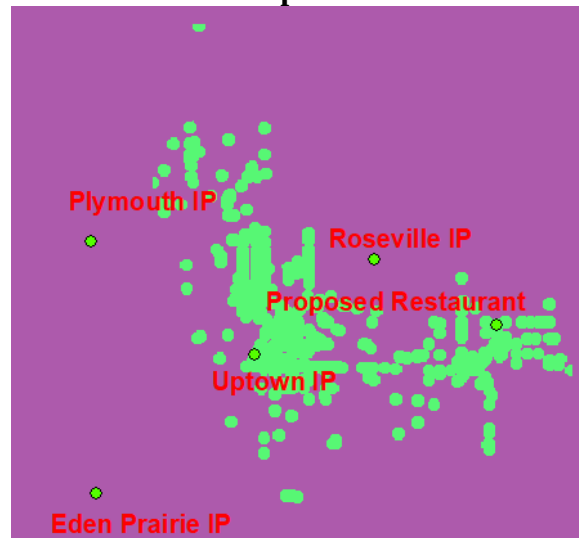
Undeveloped Area



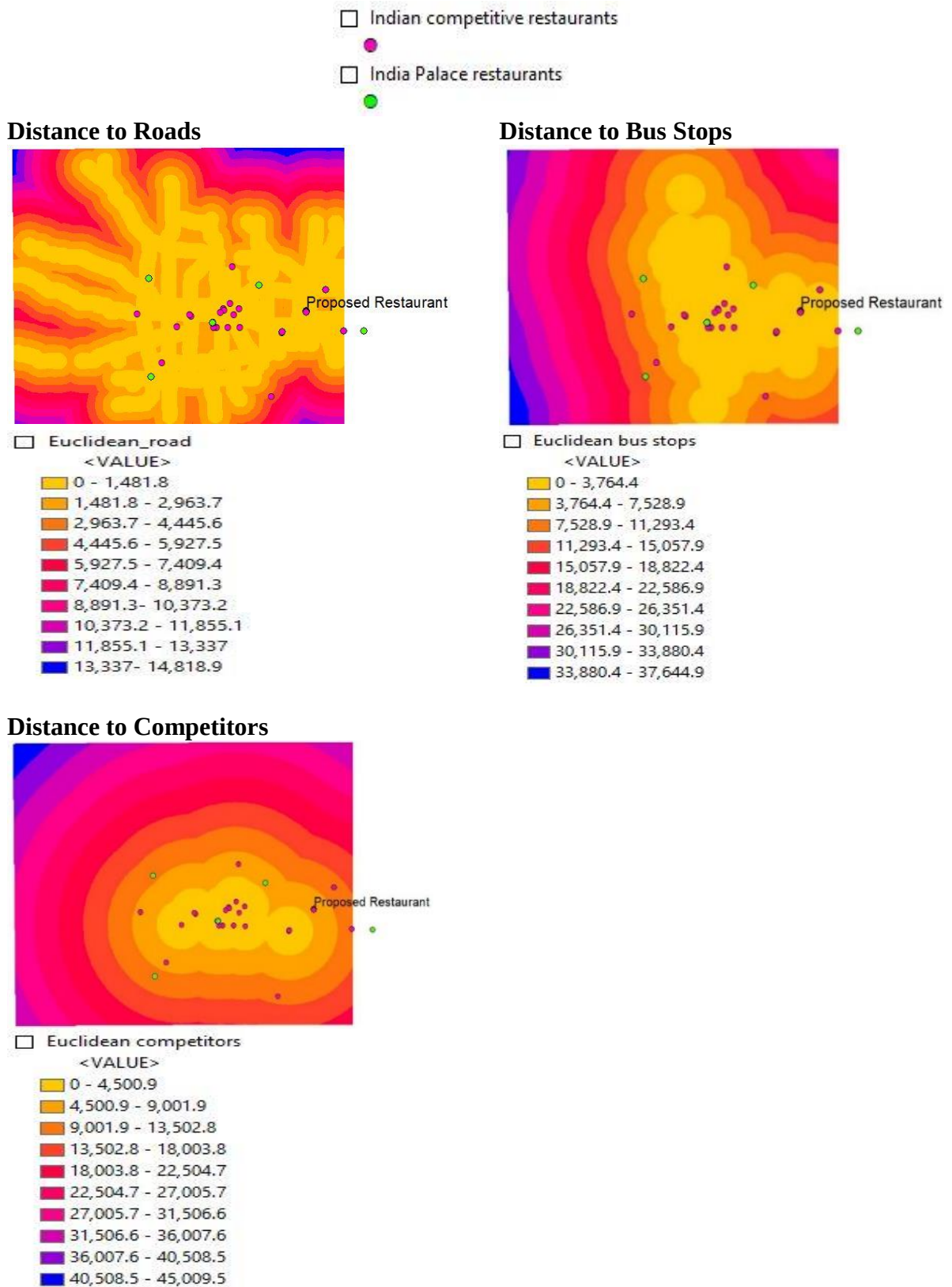
Nearest Main Road Within 500 Feet



Nearest Bus Stop within 1500 Feet

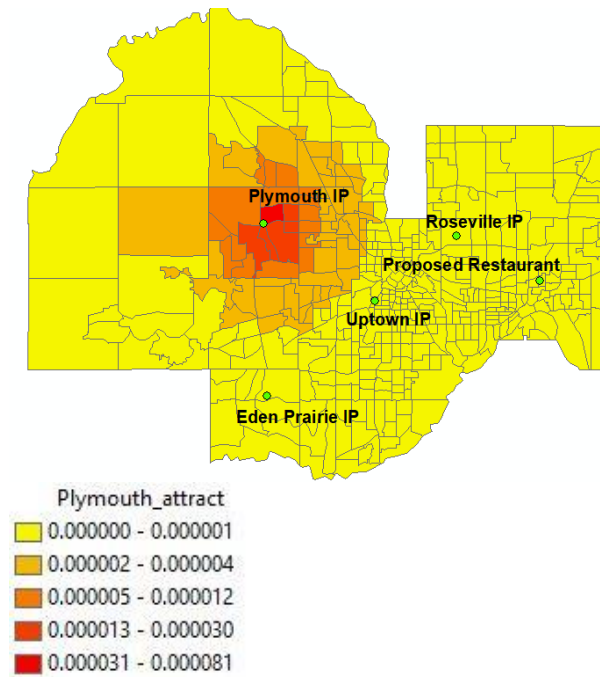


Appendix B. Euclidean distance tool applied for roads, bus stops and competitive restaurants. Units are in meters.

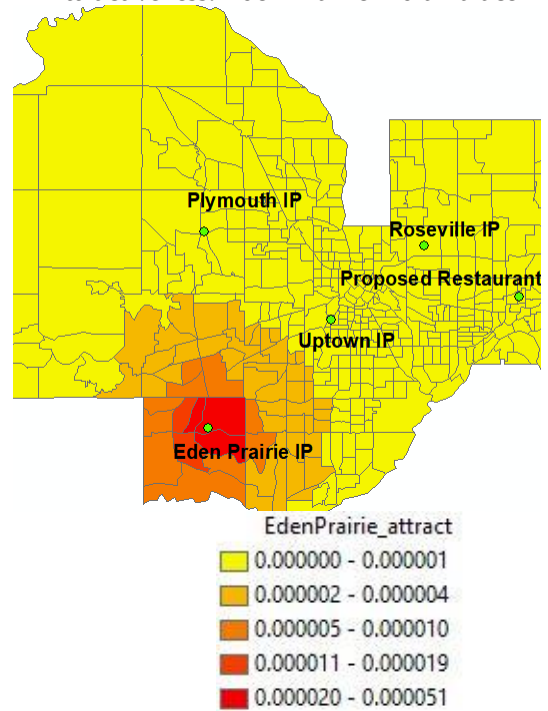


Appendix C. Calculated attractiveness for each restaurant using size of location divided by distance squared. Yellow to red represents low to high attractiveness.

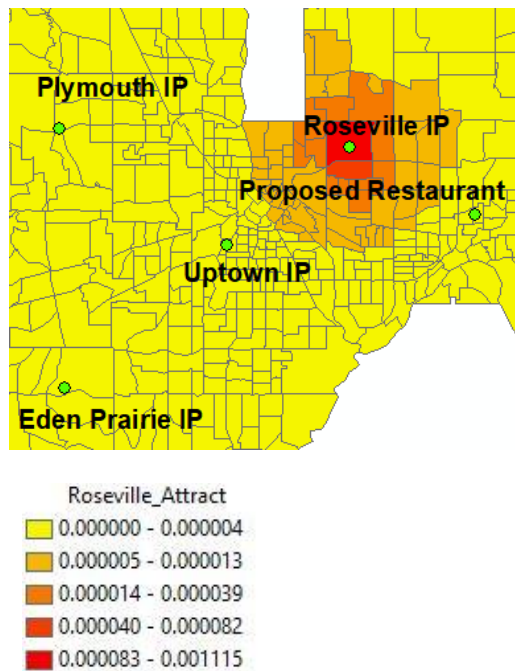
Attractiveness: Plymouth India Palace



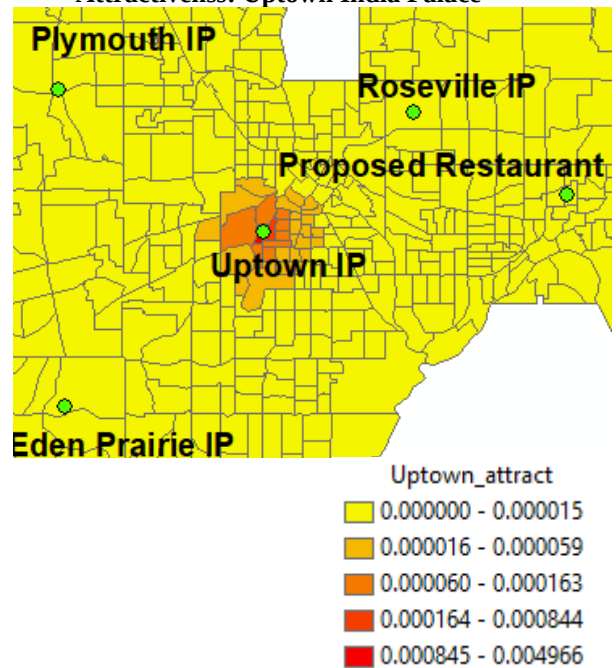
Attractiveness: Eden Prairie India Palace



Attractiveness: Roseville India Palace

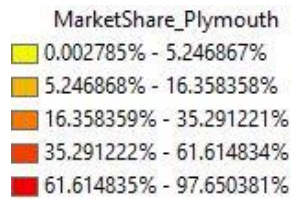
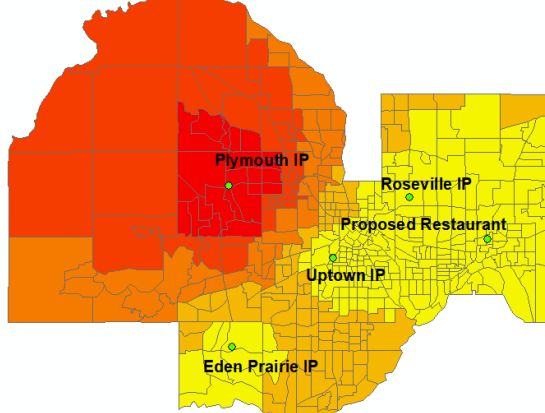


Attractiveness: Uptown India Palace

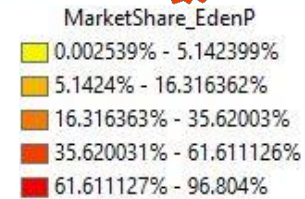
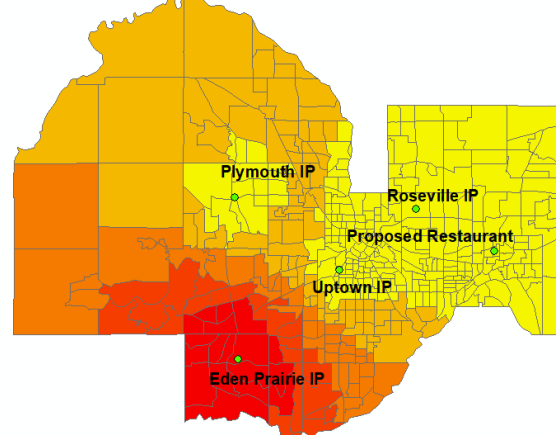


Appendix D. Market share potential of restaurants. Yellow to red corresponds with low to high market share.

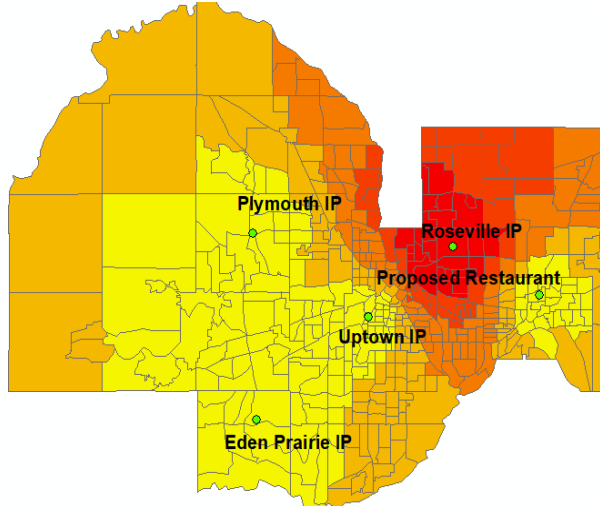
Market Share: Plymouth India Palace



Market Share: Eden Prairie India Palace



Market Share: Roseville India Palace



Market Share: Uptown India Palace

